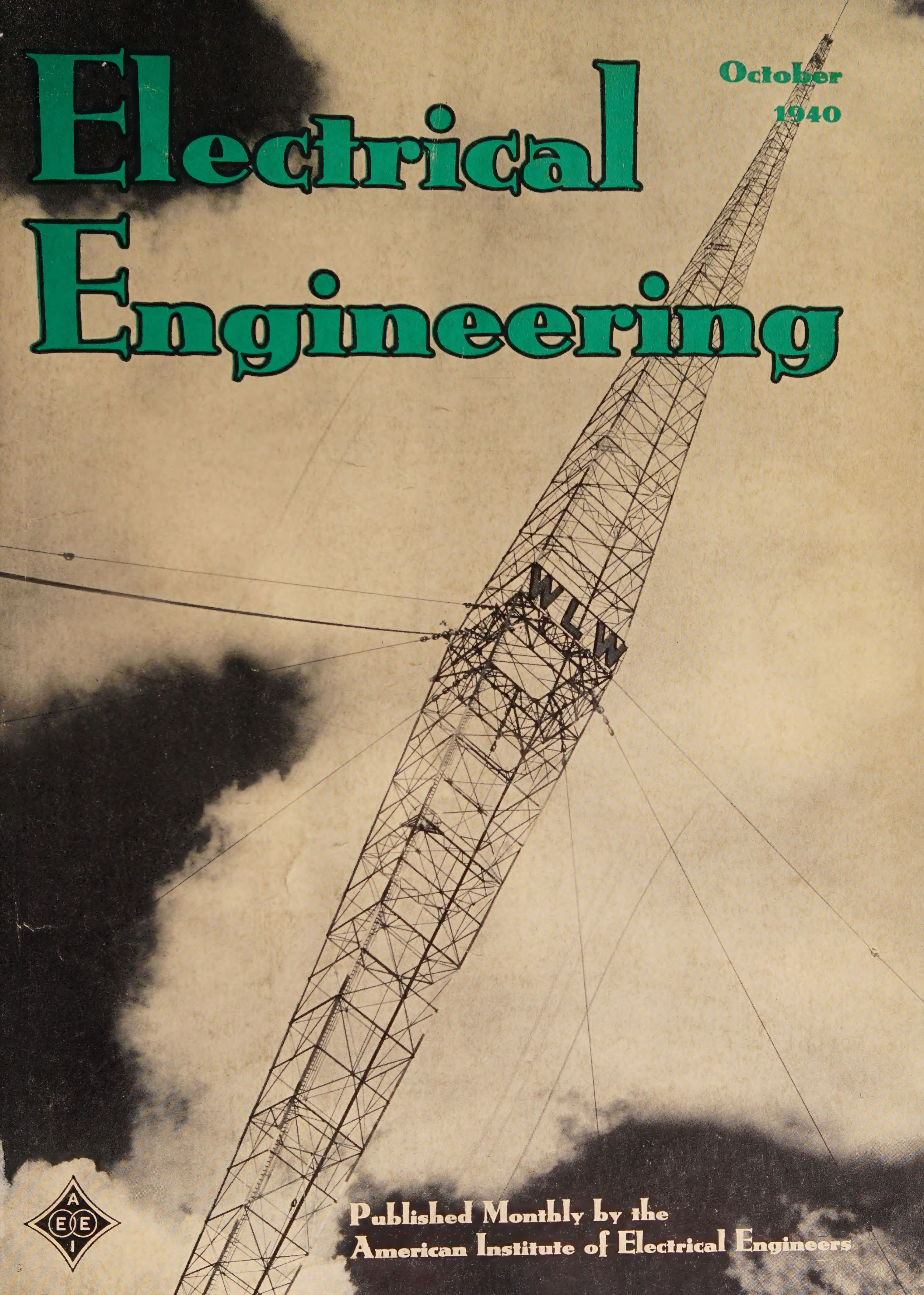
Electrical Engineering

October
1940



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Electrical Engineering

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for October 1940—

The Cover: The 831-foot vertical radiator of station WLW, Mason, Ohio; an inspection trip to the station is scheduled in connection with the Middle Eastern District meeting, Cincinnati, Ohio, October 9–11, 1940

Transactions Section *(Follows EE page 438; a preprint of pages 563–602 of the 1940 volume)*

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High Lights • •

Major System Shutdowns. Despite the efforts of central-station operators and designers to the contrary, a complete shutdown of an entire major electrical system or a large portion of one occasionally occurs. Unless proper account of such a contingency has been taken in the design and operation of the system, it may prove difficult to restore the system to service and an unnecessarily long outage may result. As an aid to those facing such a problem, papers on the design and operating practice of several large systems have been prepared. Although conclusions and procedures that result from the experience of one company may not be applicable to other systems, many of the conditions are common to all systems. Restoration of service following shutdowns from two different causes—flood and electrical failure—are discussed for the Duquesne Light Company system (*Transactions pages 563–70*). The system of the Philadelphia Electric Company has no large single blocks of load, and each load area of the system is adequate unto itself in generating capacity. Restoration of service from a complete shutdown thus may be a matter of starting each individual station, restoring the area loads, and then paralleling the sections of the system (*Transactions pages 571–4*). The bulk power system of The Detroit Edison Company is designed and operated in five power-plant load areas, which are "loose linked" to prevent uncontrollable trouble in any one of them from causing a shutdown. The areas may each be sectionalized because the distribution lines are largely radial, and the load picked up in small pieces (*Transactions pages 575–9*). The system of the Consolidated Edison Company of New York, Inc., supplies approximately 2,400,000 consumers, and to provide the high degree of service continuity required in metropolitan areas, the multiple-feed low-voltage network is used. The adopted plan contemplates that the total distribution load will be segregated into blocks which are small by comparison with the capacity of the interconnected generating stations (*Transactions pages 579–85*).

Basic Insulation Levels. As a step in solving the insulation co-ordination problem, basic insulation levels were established in 1937 as reference levels expressed in terms of impulse voltages. Refinements in testing technique since that time have made a revision desirable (*Transactions pages 596–8*). To assure satisfactory service while operating within the voltage range and under the system conditions expected, electrical equipment must be selected to conform to the requirements of the basic insulation level, and to withstand a variety of voltages imposed upon it (*Transactions pages 585–9*). A reasonable margin should be established between the voltage level held by the protective device and the various basic levels themselves to insure that adequate protection is provided (*Transactions pages 591–5*).

Rail Transport. Continued competition from the motor truck is curtailing the amount of freight shipped by rail and is forcing the railroads to modify their operating methods to expedite the movement of freight by rail. According to one authority, all indications point to an ultimate co-ordination of rail and road transport, with certain consolidations of rail lines, abandonment of others, and restriction of heavy long-haul traffic to the railways. Such a program would increase the traffic density on certain lines, making the use of electric traction, with its pronounced advantages where the traffic density is heavy, attractive and in some instances almost essential (*pages 400–06*).

Transactions Supplement. In the 1940 "Transactions Supplement" to Electrical Engineering, to be published in December, will appear 57 technical papers which will be included in the 1940 annual volume of AIEE Transactions but which will not be preprinted in the monthly Transactions sections of Electrical Engineering. Abstracts of these papers appear in this issue (*pages 413–20*).

Abstracts of Technical Papers. Some of the papers to be presented at the Middle Eastern District meeting, Cincinnati, Ohio, October 9–11, 1940, are previewed in this issue (*pages 428–30*); abstracts of the rest of the papers for that meeting appeared in the September issue.

Electricity in Medicine. The lay public has a faith in the medical value of X rays and electricity that is hardly justified, says a member of the faculty of a leading eastern medical school. Nevertheless, electricity is being used in many and varied ways by the medical profession, particularly as an aid in diagnosis. Continued experimental work is revealing new uses for this versatile agency, and in this work the active help and co-operation of the engineer are needed (*pages 389–94*).

High-Voltage Testing. Insulation co-ordination, which is the correlation of the insulation strength of electrical equipment to meet a specified level, is determined by tests, and therefore uniform testing equipment characteristics and methods are desirable. A subcommittee of the EEI-NEMA joint committee on insulation co-ordination has prepared recommendations for impulse testing and humidity corrections (*Transactions pages 598–602*).

Bushing Standards. An effort to develop more consistent standards for the electrical characteristics of bushings for different types of apparatus has resulted in recommendations for outdoor bushings by a joint committee operating under sponsorship of the AIEE standards committee (*Transactions pages 590–1*).

President's Address. Previously announced as dealing with "Science and Superstition," President Sorensen's address at the Pacific Coast convention included a number of pertinent comments on Institute activity; emphasized the necessity of greater participation by engineers in public affairs (*pages 421–4*). Other convention features are also reported (*pages 424–5*).

Determining Transformer Size. By first converting the fluctuations of a daily load cycle into a thermally equivalent rectangular load cycle, a relatively simple method of determining the size of distribution transformers has been developed, which also takes into account thermal and insulation-aging characteristics (*pages 407–12*).

The Institute and Standardization. Reviewing the standardization movement in his summer-convention address, Retiring-President F. Malcolm Farmer discusses the role the Institute has had and should have in the future in the development of electrical standards (*pages 395–7*).

Electricity on New Ship. A 2,400-kw steam-electric generating station is installed on the new steamship "America" to supply 765 kw of lighting, 550 motors, and other electrical equipment on the vessel (*pages 398–9*).

Report on Section Activities. Summarizing the results of its annual questionnaire to the various Sections, the report presented by the Sections committee at the 1940 summer convention is published in this issue (*pages 425–8*).

Coming Soon. Among special articles and technical papers currently in preparation for early publication are: an article describing the development and uses of the new electron microscope, by V. K. Zworykin (M'22); an article on trends in gaseous discharge lamps by George A. Freeman; an article on the use of the high-speed motion-picture camera in improving the design of electromechanical apparatus by J. R. Townsend; an article on ceramic insulating materials by Hans Thurnauer; an article on nomography for the electrical engineer by Guido E. Ferrara (Enrolled Student); a paper on dead points in squirrel-cage motors by Quentin Graham (A'39); a paper describing an improved type of d-c watt-meter of the shunted type by Paul MacGahan (M'15); a paper on the effect of load factor on operation of power transformers by temperature by V. M. Montsinger (F'29); a paper on frequency modulation by W. L. Everitt (F'36); a paper describing a rapid-recording a-c bridge by W. Mikelson (A'40) and H. W. Bousman (M'36); a paper describing low-voltage d-c measurements on electrical insulating oils by J. L. Oncley and W. C. Hollibaugh; a paper on a high-speed differential relay for generator protection by W. K. Sonnemann (A'38); and a paper on transient starting torques in induction motors by A. M. Wahl and L. A. Kilgore (M'37).

Subscriptions—$12 per year to United States, Mexico, Cuba, Porto Rico, Hawaii, Philippine Islands, Central and South America, Haiti, Spain, Spanish Colonies; $13 to Canada; $14 elsewhere. Single copy $1.50. ¶Address changes must be received by the 15th of the month to be effective with the succeeding issue. Copies undelivered because of incorrect address cannot be replaced without charge. ¶Electrical Engineering is indexed annually by the Institute, weekly and monthly by *Engineering Index*, and monthly by *Industrial Arts Index;* abstracted monthly by *Science Abstracts* (London). Printed in the United States of America.
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Uses of Electricity in Medicine

ORTHELLO R. LANGWORTHY

Although the lay public has a faith in electricity as a medical aid that is hardly justified, the medical uses of electricity, particularly in diagnosis, are many and varied; continued experimental studies are uncovering new applications

FROM the moment that experiments with electricity were begun attempts were made to employ it in the healing art. The Romans attempted to use the electric torpedo eel therapeutically. In modern times we may first turn our attention to Paris immediately after our own revolution when Benjamin Franklin was our first genial ambassador to France. He was interested as much in the scientific discoveries of the day as in diplomacy.

At this time the theories of Mesmer, known as the founder of mesmerism, were attracting considerable attention. Mesmer believed that the universe was permeated by invisible, intangible waves which could be sensed only by the inner faculties. Groups of individuals formed magic rings and allowed the current from a Leyden jar to pass through their bodies. Mesmer however was more interested in the mystic powers of the magnet and attempted cures through the force of animal magnetism. Probably he gradually realized that the agency responsible for his cures came not from the magnet but from the strength of his own personality.

In 1792 Galvani of Bologna made a startling discovery. He noticed muscular spasms in frog's legs suspended by copper hooks from an iron balustrade. The difference in potential resulting from accidental contact of the muscle fiber with the dissimilar metals caused a current to flow which produced a contraction of the muscle. The observation was followed up with rare skill and insight by Volta in his "experiments on animal electricity." Volta showed that a muscle can be thrown into continuous contraction by successive electric stimulations. Galvani originated the science of animal electricity; Volta developed the electric battery with its manifold applications.

Emil du Bois Reymond (1818–96) was the founder of electrophysiology. Matteucci had already demonstrated the difference of potential existing between a nerve and its damaged muscle (1838) and first noticed that the muscle of a muscle-nerve preparation will contract if its nerve be laid across another contracting muscle (1842). (This preparation is made by removing from the living animal a single muscle with its nerve supply attached.) Du Bois Reymond introduced faradic stimulation by means of the interrupted current from the special induction coil which was named after him. In 1843 he noted that difference of potential between the cut end of an excised muscle or nerve and the uninjured end produced a current which can be demonstrated with a galvanometer. Many other discoveries having to do with the potentials of a nerve-muscle preparation can be attributed to him.

Already attempts were made to use electricity in the alleviation of disease. Franklin is remembered for his letters written in 1757 describing the treatment of paralysis by electricity. Electric baths were designed in 1768; in 1767 the first static machine was installed in the Middlesex Hospital in London. In 1842 the eccentric Duchenne of Boulogne came to Paris to experiment with the uses of electricity in medicine. It was an important day when he placed two wet electrodes on the moistened skin and found that the current localized its actions on the underlying muscles and adjacent nerves. Instead of the painful and dangerous method of electropuncture he taught the physician how to limit and control electrical excitation without pricking, incising, or damaging the skin. Three papers of his stand out as masterpieces in medicine. In his report "on localized electrization" (1855) he explained his methods while in "the mechanism of the human countenance" (1862) and "the physiology of movements" (1867) he discussed muscular contractions as induced by the faradic or interrupted current. Erb in 1868 introduced the method of electrodiagnosis by galvanic and induction currents.

The work of Fritsch and Hitzig (1870) opened a whole new field for electricity in experimental work for they first demonstrated the electrical excitability of the brain. They showed that local bodily movements and convulsions can be produced by stimulation of definite areas in the brain of the dog and that removal of these areas will produce paralysis or loss of function in the corresponding parts of the body. This led to the discovery of localized areas of special function in the cerebral cortex.

The tempo of experimental work with electricity in physiology and medicine now becomes so fast that it is necessary to draw this introduction to a close. High-frequency currents were introduced by d'Arsonval (1887–92) and employed by Franz Nagelschmidt in electric thermo-penetration or diathermy in 1906 and for electrocoagulation in 1910. Ionotherapy, suggested by Edison in 1890, was introduced by Stephan Leduc of Nantes in 1900. This may be defined as the introduction of ions into the body by the electric current for therapeutic purposes. The X rays discovered by Roentgen in 1895 soon became a reliable aid in diagnosis and in the hands of experts a useful therapeutic measure. The introduction of the

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string galvanometer and cathode-ray oscillograph opened new fields for diagnosis and experimental work.

If we turn now to the present day, we can but summarize briefly the manifold uses of electricity in medicine. I have chosen to consider them under three headings as they are applied to treatment, diagnosis, and in experimental studies. Undoubtedly from experimental studies further valuable applications will be derived.

USES OF ELECTRICITY IN TREATMENT

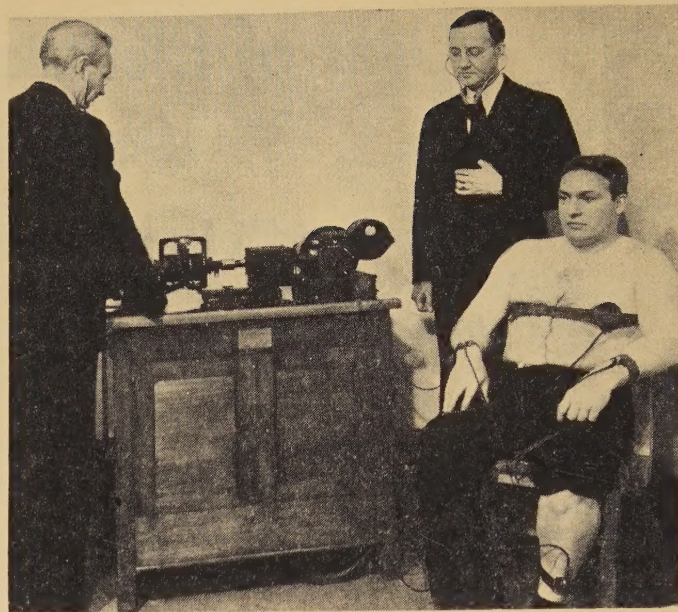
Electricity in the treatment of disease has not justified the great expectations of the earlier investigators. The most important application is a secondary one, the use of deep X-ray therapy for the treatment of tumors. This method is of greater value in some cases than others; it has been found of particular value in dealing with cancer of the kidney. Unfortunately the rays only depress the growth of the tumor for a limited time. The dermatologist uses X-ray therapy with good results in the treatment of skin diseases such as acne, or pimples on the face, and for ring worm.

It was early observed that prolonged application of the X rays led to sterility. Moreover, the application to the abdomen during pregnancy produced abnormal development of the fetus. X rays may be used to render males or females sterile.

Electric cautery has been a boon to surgery when used as a cutting loop, cutting knife, or as a ball-shaped electrode. The loop or knife can be employed to remove areas of tissue bloodlessly, since the heat tends to close off the cut ends of arteries and veins. The ball-shaped electrode is applied to stop hemorrhage. The electric needle is utilized to kill the roots of hairs.

Diathermy is widely employed at the present time either to raise the temperature of the entire body or to supply localized heat to deeply lying structures. Some years ago it was found that the attacks of chills and fever induced by an infection with malaria had a favorable influence upon the course of syphilitic infection of the central nervous system and particularly on that dread form, general paralysis. It was then suggested that the body temperature might be raised artificially by diathermy without subjecting the patient to malarial infection. This method has had considerable success, although it is still doubtful whether it gives as good results as malaria. Diathermy is also used for the treatment of gonorrhea and particularly of gonorrheal arthritis. Local application of diathermy forms a method of treatment of chronic infections.

The ionizing current is still used in medicine in efforts to apply drugs to deep structures lying under the skin. Recently in cases of arthritis an attempt has been made by this means to apply Mecholyl, a muscle stimulant. Ionization is also used in the nose and ear cavities for the application of metallic solutions to the tissues. Penetration of the ions through the skin is thought to be induced by saturating the large indifferent electrode placed over the ailing part. (This electrode diffuses the electric charge over a wide area.) Grave doubts may be entertained as to the efficiency of this method.



Cambridge Instrument Company

Figure 1. The Hindle electrocardiograph in use

Many types of lamps either primarily for heat production or for the application of ultraviolet or infrared rays are designed for use in physiotherapy. Their value is still a matter of controversy, but it is clear that in many cases they at least give the patient a sense of well-being. Radiant heat is applied to patients in shock or to paralyzed extremities. The ultraviolet lamp is used in the treatment of lupus vulgaris, a skin disease. The various lamps have been greatly overexploited from a commercial point of view.

When a muscle is paralyzed due to injury of its nerve supply it has been suggested that the application of electric stimuli, by causing contractions, kept the muscle in good condition until the connection with the nervous system was re-established. If this stimulation were to be of any value, it should be applied many times a day. Recent studies have emphasized the importance of absolute rest for paralyzed muscle, and suggested that electrical stimulation should be used only in diagnosis.

Finally we come to the dramatic cures by electricity which have intrigued investigators since electricity was discovered. These can be attained by faradic or galvanic (d-c) shocks, static machines, or any type of electrical apparatus. We may place the patient in a darkened room. The ultraviolet-ray machine splutters and sends beautiful sparks out into the darkness by means of which the faces of the doctors may be seen dimly. An application of these mysterious rays in the neighborhood of the paralyzed parts may produce amazing results in the carefully selected case. The blind see, the deaf hear, and the lame walk. Modern psychiatrists deplore these magical cures. They startle the patients into normal behavior, but offer no balm to the underlying mental disturbance which caused the individual to hide behind a protective shield of invalidism.

The lay public has a faith in X rays and electricity that is hardly justified, and as far as possible should be made acquainted with their actual value. Many believe that if a roentgenogram is taken of the ailing part, the nature of

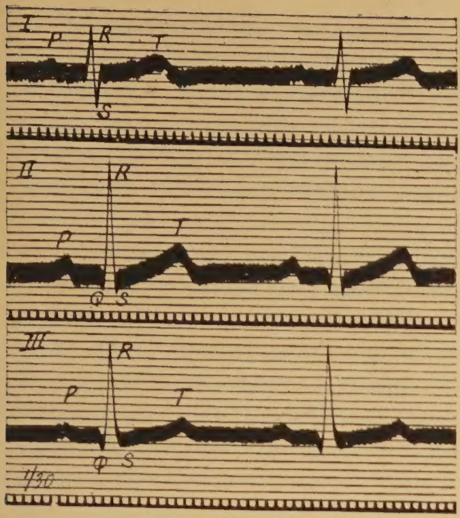


Figure 2. Electrocardiograms taken from the three common leads (from Thomas Lewis)

Leads I—Right arm to left arm

Leads II—Right arm to left leg

Leads III—Left arm to left leg

their illness is immediately apparent. Similarly they welcome enthusiastically the use of any electric device. It is unfortunate that laymen have such poor critical judgment of the proper treatment of disease. This arises partly from the fact that many ailments are of the mind rather than the body, and may be partially alleviated by mystical treatment. It is noteworthy that patients with severe mental disturbances frequently believe that they are being influenced or harmed by some form of electrical mechanism.

USES OF ELECTRICITY IN DIAGNOSIS

The use of electricity in diagnosis is of much greater value. The ophthalmoscope makes it possible to look into the eye illuminated with reflected light and observe the fibers of the optic nerve. This nerve is actually formed by an outgrowth of the brain in embryonic life so that it is possible to visualize a small portion of the brain itself. The blood vessels can be seen clearly and an opinion may be formed concerning the condition of the other blood vessels of the brain. Similarly through the external orifice of the ear the ear drum may be inspected.

One of the first uses of the electric bulb was to introduce light through the cystoscope into the bladder. With improved instruments it is possible to gaze into all the body cavities. The light, of course, is always inserted through a hollow tube. Kussmaul in 1869 was the first to attempt an exploration of the esophagus and stomach with a light inserted through the mouth. This method has been further developed, and it is even possible to take photographs of the interior of the stomach by means of a small camera introduced in this way. Similarly, foreign bodies in the trachea and bronchi may be localized and removed.

The inspection of the interior of the bladder is a common procedure in diagnosis. The orifices of the ureters may be located and urine from each kidney collected separately. Through the anus a considerable portion of the large bowel may be seen. Visual examination of other body cavities is still in the experimental stage. A tiny opening may be made in the abdomen and the structures examined by inserting a light. By a similar means it is possible to look into the fluid cavities of the brain. Portions of the body that are translucent may be illuminated and changes produced by disease may be observed. Many have had their sinuses examined in this way.

Other procedures depend upon the electrical charges of the body and changes of potential produced by physiological activity. The whole organism may be considered as a capacitor similar to a Leyden jar. Electric currents are developed at each contraction of muscles. The discharges from nerve cells appear to be of the nature of electric currents. Localized sweating of different portions of the body gives rise to differences of potential.

Waller, a German physiologist, came to visit the great English cardiologist James McKenzie and told him of the development of the string galvanometer by Einthoven, suggesting the application of this method to cardiology. McKenzie turned the problem over to his pupil Sir Thomas Lewis who is largely responsible for the development of clinical electrocardiography.

The currents developed by contraction of the heart muscle are small, but modern instruments are sufficiently sensitive to record them with facility. It is unnecessary that the heart should be exposed; the currents will deflect a suitable galvanometer when the latter is connected to the extremities of a human body. Figure 1 shows the leads attached to the patient; three connections are used, one to the right arm, one to the left arm, and one to the left leg. The string galvanometer is shown at the left end of the table; the apparatus at the opposite end consists of the camera for recording the heart action. A telephone-transmitter type of stethoscope is clamped over the patient's heart by means of a belt. In practice three electrical records are taken (figure 2): right arm to left arm (I); right arm to left leg (II); and left arm to left leg (III). The saw-tooth line at the bottom of each record is produced by the timing mechanism; the intervals are 1/25 second. The study of the electric waves recorded, their time relations, and their magnitudes constitutes electrocardiography. The three records show certain variations of value in diagnosis.

Figure 3. Normal electrocardiogram (from Thomas Lewis)

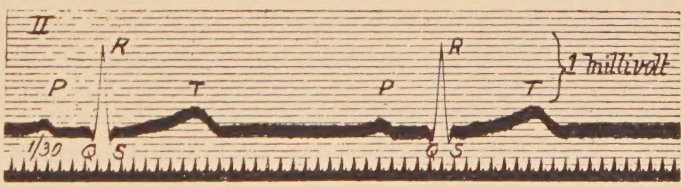
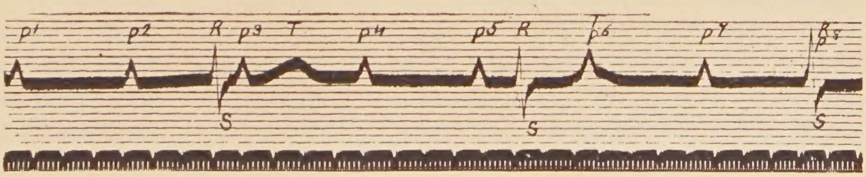


Figure 4. Electrocardiogram showing two or three auricular contractions to a single ventricular beat (from Thomas Lewis)



The heart is made up of four chambers, two auricles and two ventricles. The auricles are thin walled, and the ventricles are thick muscular structures. The right auricle receives blood from the veins and pumps it to the right ventricle; the left auricle receives blood from the lungs and pumps it to the left ventricle. Similarly the right ventricle propels blood through the lungs and the left ventricle to the arteries of the body. These muscular cavities contract in a definite sequence, first the two auricles together followed by a simultaneous contraction of the two ventricles.

Nerves terminate at the junction of the veins with the right auricle. The impulse then passes directly along the muscular wall of the auricles. It is finally transmitted to the ventricles by a specialized system of muscle fibers.

The normal electrocardiogram consists of a series of changes of potential, some of which are rapid and of short duration, while others are slow and of longer duration (figure 3). They have been named in a purely arbitrary fashion, *P*, *Q*, *R*, *S*, and *T*. The cycle begins with a blunt summit *P*, which is due to the contraction process in the two auricles. Following this deflection the string shadow either maintains the zero position or dips a little. This portion of the record is called the "auricular complex"; it begins with the upstroke of *P* and terminates at the opening of the "ventricular complex." The latter varies in the number of its component deflections; in its full form it consists of a small dip *Q*, a tall spike *R*, a dip of variable extent *S*, and a blunt broad summit *T*. The period occupied by all these deflections is approximately that of ventricular contraction with which they are associated. As may be seen from figure 2, the waves show variation of form and size in the records taken with different combinations of leads. The *R* wave is normally largest in the record taken with right-arm and left-leg leads (II). By comparison of these records the skilled electrocardiologist can make further deductions concerning cardiac function. By placing the leads on other portions of the body the form of the record can be varied further.

This method is of great value in recognizing abnormalities in conduction of the impulse through the heart muscle. Disease may injure the specialized tissue carrying the impulse from the auricles to the ventricles. Under this condition the auricles and ventricles will each beat at their own rhythm as shown in figure 4. The independent rhythm of the ventricles is much slower than that of the auricles so that two or more auricular beats will occur to each ventricular contraction. Thus in the central portion of figure 4, three auricular contractions or *P* waves occur before the ventricular contraction corresponding to the *R*, *S*, *T* waves appear. At the two ends of the graph two auricular contractions appear before a ventricular contraction. There may be an abnormal number of beats of the ventricles in relation to the auricles or they may occur prematurely. The point where the excitation of activity begins may shift from its normal position to some other part of the auricle. There may be an abnormal circus movement of the contraction around a ring of muscular tissue in the auricles giving rise to auricular flutter and auricular fibrillation which are fast irregular contractions of the auricular wall. Information can be obtained from the electrocardiograph concerning the relative development and strength of contraction in the two ventricles. It must be admitted that the electrocardiogram adds little information that cannot be obtained by careful clinical examination, but it is often infinitely more convenient.

The X ray has been of the greatest value in diagnosis. By this means defects in bony structures can usually be visualized accurately. Soft structures are more difficult to delineate because of their low density. The early development of tuberculosis in the lungs can be diagnosed, and the form of the heart is well seen. It is now possible to focus upon structures at a specific depth in the body cavities. The introduction of opaque substances has extended the field of usefulness of roentgenography. The bladder can be filled with sodium iodide and its contour visualized. Similarly the salivary glands or seminal vesicles are outlined. An iodine compound injected into the blood vessels is excreted by the kidneys and brings out the outline of the kidney pelvis and ureters. The gall bladder can be demonstrated by the injection into the blood of a bromine derivative. In recent years it has been possible to inject a substance known as thorotrast or thorium dioxide into the blood vessels and by taking a picture at once, show the vascular system of the body in the area selected for investigation. The liver and spleen are also visualized. Unfortunately, this last technique is dangerous since the substance is radioactive and is retained in the body for a considerable period.

The roentgenogram shown in figure 5 illustrates the accessory sinuses of the head. The orbital cavities and the structures of the nose may be recognized. The teeth and the extensive dental repair are visible in the lower portion. A shadow in the right maxillary sinus indicated by the arrows shows the position of an abnormal growth.

Dandy made enormous advances in the diagnosis of brain tumors when he demonstrated that it was possible to fill the ventricles of the brain with air and demonstrate their form in X-ray photographs. Any obstruction to the

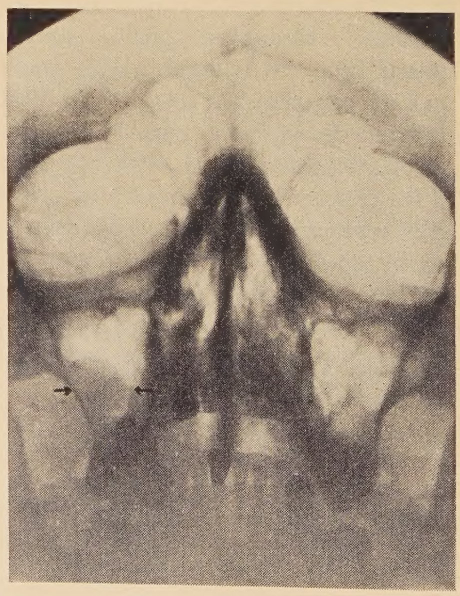


Figure 5. A roentgenogram showing the air sinuses of the head. A dark shadow in the right maxillary sinus (indicated by arrows) shows the presence of an abnormal growth

flow of cerebrospinal fluid from the ventricles causes them to enlarge. The position of the obstruction can often be visualized. Tumors or abscesses tend to bulge into the ventricles or push the ventricular system to one side. Scars pull the cavities outward toward the surface of the brain. If a spinal-cord tumor is suspected, iodinized oil is injected into the upper end of the spinal canal. If there is a block in the canal, the descent of the oil is impeded by the compression and localizes the disease.

Two roentgenograms indicate the positive and negative value of X rays in the diagnosis of brain tumors. The first (figure 6) illustrates a routine plate of the skull which does not indicate the position of the growth. The wavy lines indicate the lines of union between the bones of the skull. The position of the eye sockets and the nose can be recognized. The air sinuses above and between the orbital cavities show clearly as indicated by arrows. Figure 7 is a roentgenogram taken after the injection of air into the ventricles of the brain. Two small round holes (marked by arrows) indicate the perforations of the bone to permit the air injection. The dilated lateral ventricle on the right side of the head is filled with air and casts a light shadow. On the left the ventricle is small and pressed upon by a dark ovoid mass which is the tumor.

The fluoroscope makes it possible to obsêrve the progress of opaque substances through the gastrointestinal tract and facilitates the recognition of ulcers or tumors of the stomach and intestines.

Experimental studies of electricity as related to biology and medicine must be treated briefly; they occupy the attention of hundreds of investigators. The Johnson Foundation of Medical Physics has been established in Philadelphia, where Franklin made his first experiments. Perhaps too much attention is focused nowadays on the variations of potential in living tissue, and the fundamental observations of physiology and biology tend to be neglected. Certainly the findings obtained with complicated apparatus must be carefully checked with more direct observations of structure and function.

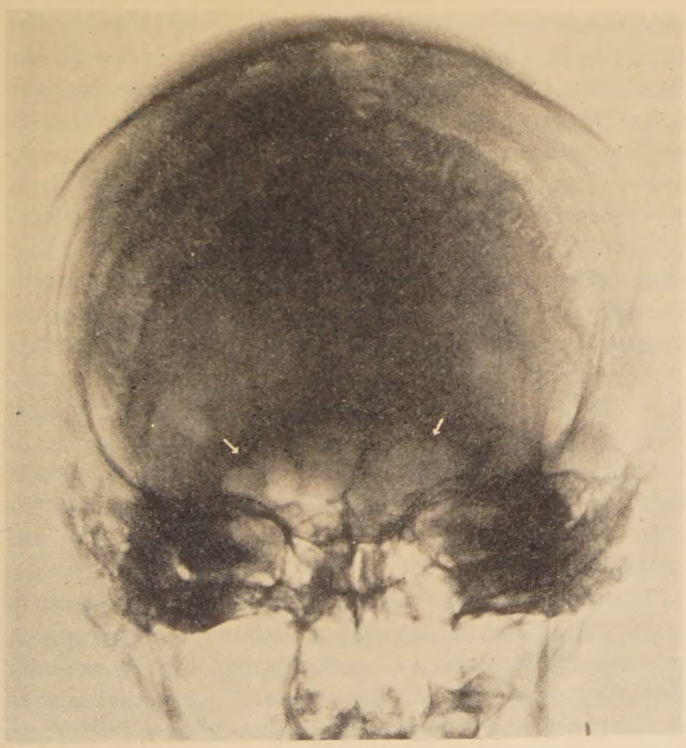


Figure 6. This routine roentgenogram of the skull of a patient suffering from a brain tumor does not indicate the position of the growth

Figure 7. A brain tumor visualized by the injection of air into the ventricles. The dilated right lateral ventricle is of light color. The left lateral ventricle is small inasmuch as it is pressed upon by the tumor, which appears as a rounded black mass

Electric currents are still used to induce activity in the brain, cord, and peripheral nerves. Foerster has stimulated almost all portions of the cerebral cortex of conscious patients after exposing the brain at operation, and has recorded their subjective sensations as well as objective contractions of groups of muscles.

The transmission of impulses along nerve fibers has been recorded. In fact it has been possible to isolate a single nerve fiber and study stimuli carried along its course. The fibers making up a peripheral nerve vary in diameter. Different types of wave stimuli are obtained from nerve fibers of varying sizes. It is possible to detect the electrical nature of the nerve stimuli by inserting a needle into the muscle and attaching an electrode to the skin in the vicinity. The nerve stimuli entering the contracting muscle may be made audible by the use of an amplifier and a loud-speaker.

It has already been pointed out that differences in the moistness of the skin surface due to activity of the sweat glands give rise to differences of potential. The galvanic skin response, which may be detected by the application of suitable electrodes and electrical measuring devices, has been used in a number of interesting ways. Variations of potential produced by emotional responses of the indi-

vidual form the basis of the much-publicized "lie detector." This method needs further studies. The resistance of the skin is changed during sleep and in certain abnormal conditions.

Brazier in London has suggested that the measurement of the power factor or phase angle of the human body gives information concerning metabolism. He has measured the phase angle at frequencies of the order of 10,000 cycles and reports a correlation between the metabolic rate and his phase-angle measurements. The author and his associates have not obtained favorable results with this method.

Doctor W. B. Kouwenhoven, Doctor D. R. Hooker, and the author have been interested in the damage produced in the body by contact with electricity. It appears that low-voltage alternating currents produce death by causing ventricular fibrillation. Contact with high-voltage circuits is likely to cause a physiological block of nerve impulses leading to the cessation of respiration.

The neurophysiologists are now occupied with the study of electroencephalography or "brain waves." Cerebral activity gives rise to variations of potential which can be led off from the surface of the head. Waves are elicited from the visual cortical areas with the eyes closed. When the eyes are opened, the waves stop due to their synchronization. It is possible that this method will eventually be of value in the localization of tumors and in the diagnosis of other diseases of the nervous system. From an experimental viewpoint it has been possible by this method to localize accurately for the first time the projection of pathways carrying forms of sensory stimuli in the brain.

The experimentalist in these fields needs the active help and co-operation of the engineer. In diagnosis and therapy the apparatus is more or less standardized. Experimental work requires adaptations to suit the problem. It is ideal when the investigator can have a training both in engineering and in medicine. This will be possible for few individuals not only because of the time and expense involved, but also because of the limited capacity of the human mind.

REFERENCES

1. The Discharges of Impulses in Motor Nerve Fibers, **E. D. Adrian** and **D. W. Bronk.** *Journal of Physiology*, volume 67, 1929, page 119.

2. Apparatus Accepted by the Council on Physical Therapy of the American Medical Association (pamphlet). Chicago, 1936.

3. Sources of Ultraviolet and Infrared Radiation Used in Therapy, **W. W. Coblentz.** *Journal* American Medical Association, volume 103, 1934, pages 183, 254.

4. Diathermy Including Diathermotherapy and Other Forms of Medical and Surgical Electrothermic Treatment (book), **E. P. Cumberbatch.** William Wood, Baltimore, Md., 1937.

5. Lewis' Practice of Surgery (book), **W. E. Dandy.** Prior Company, Hagerstown, Md., volume 12, 1933, page 89.

6. Diagnostic Roentgenology, edited by **Golden.** Nelson's Loose Leaf, New York, 1936.

7. Fever Therapy. Discussions presented at International Conference on Fever Therapy. Hoeber, New York, N. Y., 1937.

8. Muscular Contraction (book), **J. F. Fulton.** William and Wilkins Company, Baltimore, Md., 1926.

9. An Introduction to the History of Medicine (book), **F. H. Garrison.** W. B. Saunders Company, Philadelphia, Pa., 1929.

10. Electrosurgery (book), **H. A. Kelly** and **G. E. Ward.** W. B. Saunders Company, Philadelphia, Pa., 1932.

11. Injuries Produced by Contact With Electric Circuits, **O. R. Langworthy** and **W. B. Kouwenhoven.** *American Journal of Hygiene*, volume 16, 1932, page 625.

12. Clinical Electrocardiography (book), **Thomas Lewis.** Shaw and Sons, Ltd., London, England, 1931.

13. X Rays and Radium in the Treatment of Diseases of the Skin (book), **G. M. MacKee.** Lea and Febiger, Philadelphia, Pa., 1938.

14. The Treatment of Arthritis With Mecholyl Iontophoresis, **G. H. Mathae.** *Journal* Missouri State Medical Association, 1936, page 303.

15. Radiation Therapy, **I. I. Kaplan.** Oxford University Press, New York, N. Y., 1937.

16. Nervous Control of the Electrical Resistance of the Skin, **C. P. Richter.** *Bulletin* Johns Hopkins Hospital, volume 45, 1929, page 56.

17. Short-Wave Diathermy (book), **T. de Cholnoky.** Columbia University Press, New York, N. Y., 1937.

18. Electricity in Medicine, **R. E. Williams.** Electrical Engineering, volume 57, 1938, pages 237–44.

Coal for Power Generation

COAL is the fuel of the future despite that most hazardous of prognostications—dealing with petroleum and natural-gas reserves. It is true that new discoveries of the latter fuels have been keeping pace with exhaustion of older fields, but no one will admit that the oil yet to be discovered will begin to approach in quantity the proved coal reserves.

Coal has been found principally in 26 of our 48 states. Though it is generally believed that our major coal reserves are in the Appalachian region, of the $3^1/_2$ trillion tons of coal reserve in the United States as of January 1, 1919, it has been estimated that approximately two-thirds is to be found west of the 100-degree-west meridian, principally in Colorado and in the Rocky Mountain states; and the remainder east of the Missouri River. The states of greatest total production of coal from earliest record to the end of 1937 are Pennsylvania (10 billion tons), West Virginia (3 billion tons), Illinois ($2^1/_2$ billion tons), Ohio ($1^1/_3$ billion tons), and Kentucky ($1^1/_4$ billion tons). The total production from these reserves has been but 23 billion tons. It is evident that the western coal reserves have scarcely been touched and that less than one per cent of all our vast coal reserves have been mined.

Because of the overproduction within the industry, of the competition with oil and gas, of importations of fuel oil, and of hydroelectric plants, it seems unbelievable that average coal prices will vary more than a very few per cent for many years to come. As a matter of fact, more widespread mechanization of coal mines plus some freight-rate readjustments may result in somewhat lower coal prices in the future, at least until it becomes necessary to start mining less desirable reserves. Even a ten per cent change in the delivered cost of coal to a modern power plant will amount to but 0.2 mill per kilowatt-hour in the cost of production of power, and almost never have fuel prices varied that much.

The remarkable fuel records of modern power plants of both utilities and industry seem to show conclusively that coal can and probably will be the source of low-cost power for many generations in the future. The actual cost of power generation is approximately one-third of its average selling price, indicating that the greatest opportunity for reducing power costs lies in transmission and distribution.

Abstracted from an article "Coal for Power Generation" by C. Y. Thomas, published in *Civil Engineering*, August 1940, pages 497–500.

Standardization and the Institute

F. MALCOLM FARMER
PRESIDENT AIEE, 1939–40

During the past three decades, standards and standardization have become an increasingly prominent subject of discussion in technical circles. They are an important part of the activities of many of the influential organizations associated with industry that have developed during this period. In more recent years, this interest in standardization has extended to many nontechnical fields, including that of the marketing of so-called ultimate consumer goods.

The purpose of this article is to review briefly the standardization movement and the Institute's participation therein. More active leadership in standardization in the electrical-engineering field is advocated. A statement of Institute policy on standards matters embodying that idea is proposed.

STANDARDIZATION

One definition of the word "standard" still to be found in the dictionary is that it is "an established measure of extent, quantity, or value". The scope of the term, however, long since has been extended much beyond these narrow limits. In commerce, industry, and engineering, the term "standardization"—that is, the establishing of standards—may be described broadly and briefly as the codification of established or desired practices. These range from simple units of measure to specifications for materials and standards of industrial practices.

Standardization probably has been one of the more potent influences in the advancement of civilization. For example, it is difficult to conceive a people developing any kind of a society or making any advance in what we call civilization without a language, yet a language is merely the standardization of the spoken and written means of communication between the members of a particular group of the world's inhabitants. In fact, the proponents of a universal or world language contend that it would greatly accelerate further advance of civilization. However, recent events seem to indicate that far more than a universal language will be required to accomplish very much in that direction.

In engineering and the allied sciences, standardization is a first essential in the orderly development of scientific and engineering knowledge for the benefit of mankind. It is self-evident, for example, that without standards of measurement of the various physical quantities with which the scientist and engineer deal interchange of new knowledge would be greatly restricted; no "yardsticks" would be available for determining the amount of progress that is being made; and the application of new knowledge to useful purposes would be seriously hampered.

Industry could not be what it is today without standardization. In industry and in commerce, standardization, in a large measure, has been responsible for making possible the mass-production method of manufacturing so highly developed in this country. The mass-production method in turn has made our standard of living the highest in the world. It is indeed true that many of the comforts of modern life, after having been made possible through engineering achievement, are made available to most of us only through this application of standardization. The modern automobile, particularly its power plant, is a wonderful engineering achievement, but its enjoyment by the great majority of people in this country is made possible only through the mass-production method of manufacture, the practical application of highly developed standardization.

A criticism of standardization occasionally heard is that, because standards of measure are permanent, stable, and uniform, therefore standards in engineering and industry must tend to exert a regimenting influence and to retard progress by "freezing" current practice. The evidence on every hand and the rapid extension of standardization in recent years refute any such contention. It is quite true that standardization can have a retarding influence if it is not carried on in a manner which will permit prompt revision of standards when circumstances so require. There is seldom, however, any valid reason why prompt revisions cannot be made.

Standardization matters have not escaped the increasing tendency of government to regulate our affairs, particularly those in which the ultimate consumer is supposed to have a direct interest. One serious objection to government control of standards is this matter of rigidity—the difficulty of making changes with progress in the art. This is doubtless due to the slow tempo that is apparently an inherent characteristic of the legislative process. Another and perhaps more important objection 's that generally speaking government representatives cannot have knowledge and experience concerning problems involved in engineering and industrial standardization equal to those of people whose vocation is in the field of such standards. In spite of the objections cited, however, certain classes of standards should, in the public interest, be under government control; notably those having to do with public health, safety, and defense. But with respect to engineering and industrial standards, it is contended that engineers and industry should assume and retain full control of their standardization needs, if the restrictive influence of government control is to be avoided and the maximum benefits of standardization are to be had.

Presented as the address of the retiring president at the AIEE annual meeting held during the summer convention, Swampscott, Mass., June 24, 1940.

SPECIFIC PURPOSES OF STANDARDS

The various specific purposes of standards in science, engineering, industry, and commerce, those fields with which we are principally concerned, may be summarized briefly as follows:

1. To facilitate the interchange of knowledge through the standardization of terms, definitions, abbreviations, etc.

2. To facilitate buying and selling by means of purchase specifications which eliminate misunderstandings and controversies and place competitors on the same basis.

3. To facilitate and reduce the cost of production. This comes about, first, because standards, in the form of specifications for raw materials based on research and experience, insure that the final product, which may not be completed for months or perhaps years, will serve its intended purpose satisfactorily; and second, because manufacturing standards are a vital factor in modern mass-production methods which are so essential for low costs.

4. To reduce the cost of production, distribution, and utilization through simplification—that is, standardization on fewer sizes, shapes, kinds, and styles by elimination of those which are not really necessary.

5. To reduce human as well as economic waste through safety codes.

6 To improve conditions in the service branches of industry (as distinguished from manufacturing) through recommended-practice standards.

TYPES OF STANDARDS

Practically all standards may be classified in one of three general groups: first, according to the field of application—fundamental, industrial, or commercial; second, according to the type—measurements, constants, quality, performance, or practice; and third, particularly for industrial standards, according to the auspices—individual companies, societies or associations, nation-wide groups or international groups.

In industry and engineering, the various types of standards for all practical purposes may be classified as follows:

1. Standards of measurement—primary and secondary.

2. Terms and their definitions; abbreviations and symbols.

3. Dimensional standards—that is, standards that deal only with dimensions or other basic quantitative limits, such as weight.

4. Specifications for materials and products which are to be used for purchasing, manufacturing, construction, and similar purposes.

5. Methods of test for materials and products.

6. Performance standards—that is, specifications with respect to requirements as to performance, ability to render the expected service, durability, and safety.

7. Safety standards—practices that will enhance the safety of workers in industrial establishments.

8. Recommended-practice standards with respect to processes, procedures, etc.

9. Preferred number standards—that is, recommended optimum number of sizes, types, grades, etc.

THE AMERICAN STANDARDS ASSOCIATION

It has been pointed out that many of the large number of organizations of individuals and of industrial concerns which have been established to promote mutual interests have made the development of standards an important activity. But the increasing overlapping of the various branches of industry and engineering incident to the rapid industrial expansion in the early part of the century developed a need for a co-ordinating agency to deal with standardization matters in those fields. Thus, in 1918, the American Engineering Standards Committee, the predecessor of the American Standards Association, was established for purposes which are stated in its constitution as follows:

"1. To provide systematic means by which organizations concerned with standardization work (including government) may co-operate in establishing American standards in those fields in which engineering methods apply, to the end that duplication of work and the promulgation of conflicting standards may be avoided.

"2. To serve as a clearing house for information on standardization work in the United States and foreign countries.

"3. To further the standardization movement as a means of advancing national economy, and to promote knowledge and use of approved American industrial and engineering standards both in the United States and in foreign countries, but not to formulate standards.

"4. To act as the authoritative American channel in international co-operation in standardization work, except in those fields adequately provided for by existing international organizations."

It is to be noted that the Association itself is not a standards-making body, but rather a federation that provides machinery by means of which the various organizations and groups interested in standards in the same field can join in arriving at standards that are acceptable to all interested and therefore truly may be considered American standards. The basic philosophy of the relatively elaborate procedure which the Association has set up for carrying out its objectives is that a standard may be designated as an "American standard" only when all of those organizations having a substantial interest in it have recorded their affirmative acceptance.

The Association now has a membership of 75 member bodies and associated member bodies, and over 2,000 company members. Its activities are carried on by over 375 committees with a total membership exceeding 3,000 individuals. It is governed by a board of directors responsible for policy and finances. All matters having to do with the approval of standards are within the sole jurisdiction of the Standards Council, a large body composed of one or more representatives of each member body. Under this council are correlating or industry committees which function as subcouncils in the individual industrial fields or deal with matters of common interest to several industries, such as safety regulations, for example.

THE INSTITUTE AND THE ASA

The Institute was active and influential in bringing about the organization of the predecessor of the American Standards Association in 1918, because in no branch of industry and engineering was there greater need than in the electrical field for some channel through which the conflicting interests of the many groups involved could be compromised and true industry standards developed. The Institute has always been prominent in the management of the Association, being represented by leading members on the board of directors, the Standards Council, and the electrical standards committee, which is the co-ordinating committee for the electrical industry. In addition to representatives of the Institute, the electrical standards committee is made up of representatives of the American Society for Testing Materials, the American

Transit Association, the Association of American Railroads, the communication interests, the electric light and power interests, the fire protection interests, the Institute of Radio Engineers, the National Electrical Manufacturers' Association, and the Department of Commerce and War and Navy Departments of the United States. It serves as an advisory committee to and a clearing house for the Standards Council on all standardization matters in the electrical field which are brought to the Association.

THE INSTITUTE'S STANDARDIZATION ACTIVITIES

The records of the Institute show that the formulation of standards in the field of electrical engineering was one of the most important of its early activities and that this has continued to be the case in varying degrees ever since. However, in recent years there has developed among some of our members an impression that after the organization of the American Standards Association the Institute has become less active and less prominent in standardization affairs. It has been erroneously intimated, first, that the ASA is an "overlord" in standardization matters, and hence the Institute has yielded a leading position with respect to standards in its own field; and, second, that the Institute has lost prestige and has become less active in standardization work.

As to the first of these assertions, it already has been explained that the Association is simply a federation of organizations interested in making standards and therefore is not a superbody. No member organization yields in the slightest degree any vested interest in a standard which it may seek to have approved by the Association as an American standard.

With respect to the second intimation—decrease in prestige and activity, it is a fact that the Institute's activity in the standardization field has probably been greater rather than less. However, much of our work is in co-operation with other bodies through the sectional committees of the ASA rather than under our own standards committee, and as a result, it is not as well known to our members. Even though the Institute is the sponsor for many of these sectional committee projects and consequently bears a major portion of the burden, the Institute is only one of several co-operating organizations. Therefore, the Institute's work does not appear to be as prominent as when these projects were carried on solely within its own ranks.

As to prestige, the question may be asked—is anything lost in submitting to a process by means of which a standard becomes certified as acceptable to everyone substantially concerned with it, rather than to electrical engineers only? Certainly such a standard means more, is more used, and is more useful, and after all, that is what should concern us most. The electrical art is now far too broad, has too many ramifications, and embraces too many groups for the Institute (with a few possible exceptions) to be the sole arbiter of electrical-engineering standards, as was properly the case in the early days of the art. However, even though the Institute is only one of several co-operating agencies, it can and should take a leading position in all standardization matters in which electrical engineering is involved.

Although the intimation that our standardization work has slackened under the ASA machinery is not justified by the facts, it is undoubtedly true that the Institute has not been the active leader in electrical-engineering standardization that it could and should be. One of the two objectives of the Institute, as stated in our constitution, is "the advancement of the art," and certainly there is no more constructive way of carrying out that objective than by taking a leading part in the development of standards in the electrical industry. Furthermore, it is specially appropriate that such a part should be taken by engineers, not only because of the highly technical character of most of the standards concerned, but because engineers are particularly well equipped for the job by virtue of their inherent qualifications, by their training, and by their experience.

In proposing that the Institute should be more aggressive in these matters, it is not intended that we should claim jurisdiction over all such standards, but merely that we take an active, leading part in their development, whether or not they are carried through to completion and promulgation solely under Institute auspices. The number of standards which properly belong only in the Institute will always be relatively few. The great majority will involve other interests—manufacturing, public utility, commercial, distribution, and government—and they therefore should be developed under the ASA procedure, but with our active co-operation.

It may seem that it will not always be easy to determine just who should assume the leadership in some of these standardization projects, but that is where the electrical standards committee assumes the role of umpire on behalf of the entire electrical industry. But even in those cases where leadership should be with other interests, the Institute frequently can do much constructive preliminary or exploratory work before bringing the project to the electrical standards committee for discussion and assignment to a sponsoring body.

STATEMENT OF INSTITUTE POLICY

Apparently the Institute never had formulated a comprehensive policy concerning its standardization activities. A statement based on the preceding discussion therefore has been proposed as the declared policy of the Institute in connection with standards and standardization where electrical engineering is involved. This statement was approved by the standards committee, March 26, 1940, and by the board of directors, May 24, 1940, and was published in the July issue of ELECTRICAL ENGINEERING, page 306. With the adoption of this policy by the Institute and the assumption of aggressive, energetic leadership in standardization matters involving electrical engineering, we shall be contributing in a most practical way to the advancement of that art. This in turn is ultimately for the public welfare, so that by contributing freely of our energies and of our special abilities in these matters, we shall be rendering the kind of service that distinguishes truly professional men.

Electricity on the Steamship "America"

A 2,400-kw steam-electric generating plant supplies electricity for lighting and power uses on this newest and largest American-built merchant vessel

CONSIDERED to be "easily the safest passenger liner in existence" the steamship "America" recently placed in service by the United States Lines Company is said to be the largest merchant vessel ever built in the western hemisphere. The new liner has an over-all length of 723 feet, an approximate gross tonnage of 27,000, and is capable of a speed in excess of 22 knots. Accommodations are provided for 543 cabin-class, 418 tourist-class, and 241 third-class passengers, in addition to a crew of 643. Originally intended for service between the United States and Europe, the vessel now is being used for "cruise" service to the West Indies.

The ship is propelled by two propellers driven at a speed of 128 rpm by two sets of triple-expansion turbines developing 34,000 horsepower. Steam is supplied from six three-drum-type boilers at a working pressure of 425 pounds per square inch and a total steam temperature of 725 degrees Fahrenheit. Each of the six boilers is fired by six mechanical atomizing fuel-oil burners. Most of the auxiliaries are electrically driven, as are all pumps normally in operation, except the feed pumps which are of the turbine-driven centrifugal type. Steam reciprocating pumps are provided for emergency use.

The connected electrical load on the new liner comprises a total of 5,337 kw, as follows: motors, 3,465 kw, including eight elevators and eight dumbwaiters; lighting, 765 kw; electric cooking and baking equipment in the galleys, 839 kw; heating and miscellaneous, 268 kw. The electrical installation to supply these services is noteworthy in the arrangements that have been provided for the generation and distribution of power under conditions of emergency operation.

GENERATING PLANT

The main generating plant consists of four geared 120–240-volt 3-wire d-c turbogenerators each rated 600 kw, with an overload rating of 125 per cent for two hours and 150 per cent for five minutes. The emergency generating plant consists of a 150-kw 120/240-volt 3-wire d-c compound-wound generator coupled directly to a Diesel engine. It is located in the dummy (forward) stack above the highest deck, and is independent of any other auxiliary on the vessel.

For automatic and instantaneous supply to the "preferred" emergency circuits for light and power, there is provided a 240-volt storage battery with a capacity of 200 amperes continuously for two hours. For the stateroom call bells and other low-voltage interior communication systems there are provided duplicate, 24-volt storage batteries. It is estimated that the capacity of each battery is sufficient to operate the system at normal demand for one week. Two batteries similar in type, rating, and arrangement to those for the interior communication systems are provided for the fire-alarm system. All batteries are automatically kept in a fully charged condition.

Two d-c–a-c motor generators each with an output of 10 kw (15 kva), 120 volts, 60 cycles, single phase, are provided for power supply to Selsyn-type telegraphs, motion-picture equipment, and other appliances requiring alternating current.

DISTRIBUTION SYSTEM

The main switchboard is of the conventional "live-front" type with fused lever switches up to a rating of 200 amperes and carbon circuit breakers for feeders beyond the capacity of 200-ampere fuses, all mounted on marine-finished asbestos-lumber panels. On each generator panel is mounted a 3,000-ampere circuit breaker, a generator switch, and a full complement of pilot lights, instrument switches, and instruments.

The emergency switchboard is of the same type as the main switchboard and is located in the emergency generator room. For convenience the interior-communication and battery-charging switchboards are combined with the emergency switchboard as one structure which contains also the automatic bus-transfer contactor for battery supply to the preferred emergency circuits.

The emergency switchboard is normally fed from the main switchboard through the interconnecting bus feeder run from an overload circuit breaker on the main board to one side of a double-throw lever switch on the emergency board. Upon failure of the main supply the bus transfer contactor operates instantly and automatically to transfer the preferred emergency circuits to the emergency lighting and power storage battery, and upon restoration of main supply, or establishment of emergency generator supply, these circuits are automatically returned to the generator bus. If the main generator supply cannot be immediately restored after failure, the emergency generator is started and the general emergency load is connected to the emergency generator by manual operation of the double-throw lever switch.

The main switchboard controls feeders to the emergency switchboard, three "primary" distribution switchboards for lighting and power, the galley power distribution switchboard, numerous power distribution panels throughout the vessel, and direct feeders to a limited number of auxiliaries. From the primary switchboard feeders emanate to lighting distribution panels, power distribution panels, and certain individual auxiliaries. The arrangement of the distribution system to suit the watertight sub-

Abstracted from a paper "The United States Liner 'America'", by Harold F. Norton and John F. Nichols, presented at the Spring meeting of the Society of Naval Architects and Marine Engineers, Newport News, Va., May 17, 1940.

division and "fire zoning" of the vessel, the protection of vital cables from damage by fire or collision, and the development of wiring methods and appliances to suit the presently required fire-resisting construction, particularly of stateroom subdivision bulkheads, have constituted the major problems of electrical design for this vessel.

LIGHTING SYSTEM

The most unusual feature of the lighting system for this vessel is the extensive application of totally indirect lighting and the consequent high total wattage of lamps. Cabin and tourist-class public space lighting is practically all of the indirect type using concealed coves and long troughs extending in some cases the full length of the room. The fixtures in the principal cabin and tourist-class public spaces have alternate lamps arranged on separate circuits to permit subdued and even lighting by the cutting out of one-half of the lamps. In the cabin ballroom, cabin lounge, tourist lounge, and third-class lounge this system is supplemented by a dimmer arrangement, permitting any degree of illumination from full bright to blackout. In the cabin lounge and ballroom the dimmers are motor operated and remotely controlled by master switches. For the cabin-lounge stage, foot and border lights in color with dimmers are provided.

All staterooms and passages are supplied by two independent circuits so that none of these spaces can be put in darkness by the failure of one circuit. This is in addition to the emergency exit lighting required by law.

Lighting in passenger staterooms, third-class public spaces, officers' and crew's quarters, machinery spaces, cargo spaces, etc., is of conventional type, except for the universal use of anodized aluminum or solid bronze lighting fixtures in lieu of the usual plated finishes. In addition to the usual complement of running, signal, and anchor lights, there are other lights fitted to meet British and German harbor regulations and canal rules. Floodlights are arranged for illumination of the water along the ship's sides when handling lifeboats, and floodlights are provided for illumination of the two stacks. The total number of lighting fixtures is 7,278; the total number of lamps is 14,500, aggregating 765,000 watts.

All power equipment, except certain portable or semi-portable equipment with motors of fractional horsepower rating, operates on 230-volt direct current and is generally of conventional type. A total of 751 12-inch three-speed oscillating marine-type bracket fans is provided. Exclusive of bracket fans, there is a total of 550 motors on the vessel of ratings ranging from 1/8 horsepower to 150 horsepower, the total combined rating of which is 4,038 horsepower.

COMMUNICATION SYSTEMS

Provisions for interior and exterior communication include unusually complete facilities for the transmission of orders for ship control and navigation, for detection of fire, for alarm in case of emergency and for subsequent direction and control of passengers and crew, for comfort and convenience of passengers, and for radio communication. The most modern navigating equipment is provided, including gyro-pilot, fathometer, pitometer log, and radio direction finder.

For ship control and navigation there are provided electrical self-synchronous telegraphs supplemented by mechanical telegraphs and "sound powered" telephones supplemented by voice tubes. In addition to its emergency use for indicating dangerously shallow water, the fathometer is used to determine the ship's position by checking the contour of the ocean's bottom indicated by successive depth readings against that shown on the chart. The pitometer log indicates the ship's speed in knots and integrates the distance traveled; with the course recorder chart this instrument provides an accurate basis for dead reckoning when the weather does not permit observations.

The fire alarm equipment is of the latest supervised type and is similar in design to the equipment developed for naval vessels. On account of the fireproof hull construction, thermostats are not fitted in the staterooms, but are fitted in the public spaces, lockers, and storerooms. The general announcing system provides loud-speakers for direct communication from the ship's officers to the fire-fighting crew quarters and to the boat-handling and embarkation stations. This should be of great assistance in preventing panic in case of collision, fire, or other casualty. An independent system is provided for radiobroadcasting and for making announcements of general interest to the passengers.

The passengers' call bell system consists of "steward" and "stewardess" call buttons in each stateroom registering on local annunciators in the passageways; each of these annunciators has an extension call on group annunciators in pantries; each of these group annunciators has a further extension call on a single central supervisory annunciator that may also be used as the service annunciator during periods of minimum activity.

The radio equipment is designed for both low- and high-frequency transmission and is arranged for two-way ship-to-shore conversations.

Modern Rail Transport

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ASSOCIATE AIEE

Because of diversion of traffic to the highways, the railways have experienced severe reductions in operating revenue over the past several years. Since revenue must cover operating expenses and fixed charges, to remedy this condition the traffic density must increase and the operating expenses per traffic unit must be reduced. This article discusses the achievement of this by suitable co-ordination of rail and road transport, with certain consolidations of rail lines and restriction of heavy long-haul traffic to the railways. Such a program introduces important engineering problems, and the problem of motive-power adequacy is discussed with particular reference to steam and electric locomotives. A short outline of other important developments in rail transport also is included.

THE most important problem facing the railways today is that of maintaining revenues and financial structures in the face of falling traffic. Since the advent of the automobile a great deal of the most profitable land transport business has been diverted to highways, and this has resulted in a general decrease in net railway revenue, despite the fact that this same period of decreasing traffic witnessed a general rise in productive activity and the use of manufactured consumers' goods.

Nor is this diverted traffic confined to short hauls and to packaged or small-bulk commodities. For example, it is estimated that about 3,000,000 tons of anthracite coal are hauled annually by motor truck from the Pennsylvania mines to the centers of population in Philadelphia, Pa., and New York, N. Y.; and the haulage of perishable foodstuffs by highway from Florida and other southern states to the markets of the north Atlantic seaboard is now a business of large proportions.

This change in the transportation structure has appeared in varying degree in all countries—in many cases so far that the railway system is threatened with bankruptcy, and in all cases to such an extent that a solution has been, or must be, found.

The cost of producing a unit of transportation by rail is made up of the actual operating cost, including train-crew wages, fuel and supplies, maintenance of way and rolling stock, etc., plus a portion of the fixed charges on the investment in the railway property. If the actual cost per unit of transportation produced is to be low, obviously the fixed charges must be distributed among a large number of traffic units. When the traffic density decreases to a value close to or below the economic operating point, there are several courses of action that may be taken all of them radical but nonetheless essential.

A possible but specious remedy for the financial difficulty is to establish state ownership and operation, whereby operating deficits are made up out of taxation. In 1937 existing well-established and privately owned railways were taken over by the Government in Mexico in accord with the Government policy of socialization, and in France in the interest of efficiency and consolidation. The British railways were subjected to radical interference by the Government under the Transportation Act of 1921, being consolidated into four large systems with the elimination of about £100,000,000 of capital.

The trend of railway-traffic diversion to the highways is most pronounced in the U.S.A., but there has been no serious agitation for Government ownership as a solution of the problem of properly co-ordinating rail and road transport to give the most economical operation of the whole transportation system. The Federal Government, through the agency of the Interstate Commerce Commission, is authorized to regulate only interstate transport, and it seems that if any policy of co-ordination and consolidation of the United States railways is to be carried out, as was done in England, it must be commenced, if not carried to its conclusion, by private enterprise with constitutionally limited assistance from the Federal Government.

In fact, under the pressure of economic necessity, there has been for some years a steady progress toward a more logical organization of transportation methods. At the outset we recognize the fact that the railways can handle heavy long-haul traffic more economically than any other land transport agency. We also recognize that for collection and delivery of freight in metropolitan areas, and indeed for most consignments to points within 50 to 100 miles of the consignor's premises, transport by motor truck is more expeditious than by ordinary rail-freight service. Another defect in the railway organization of freight transport is the loss of time incurred in classification yards and at transfer stations.

There has been a pronounced tendency in recent years for business to be conducted with reduced inventories, which makes quick deliveries essential. The motor truck provides one good means of giving this rapid service in shipment of moderate consignments over moderate distances. Twenty-four-hour delivery at distances up to 400 miles or so has come to be a regular and reliable service. Under the traditional operating methods of the railways a shipment consigned to a point 400 miles away could be counted on to take several days in transit; with present business methods, such delays are intolerable. Under pressure from customers on the one hand, and from truck competition on the other, then, the railroads have

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1. For all numbered references see list at end of article.

been forced to modify their operating methods to expedite the movement of freight over their lines. This by no means has been forced to the point where it can be said that no further improvement is possible, but all indications point to an ultimate organization of the transport system on some such basis as this:

1. Rail transport, in heavy fast trains, is a means by which huge quantities of transportation can be produced very rapidly, particularly where long distances are concerned; for example, certain railway systems today are producing transportation at an average rate of about 60,000 gross ton miles per train hour, this being an average for all trains operated on these systems. With such performance, trains are easily capable of removing freight from a terminal at the rate of 10,000 net tons per hour. It is inconceivable that any reasonable assignment of highway vehicles could handle traffic at such a rate. Therefore heavy long-haul traffic will be concentrated on the railway lines, such traffic being excluded from the highways.

2. Collection and delivery service in standard railway practice, where there exists in any metropolitan area a multiplicity of freight stations and industrial sidings, is slow, inefficient, and costly. The tendency is toward elimination of these facilities, freight being picked up or delivered at the customer's door from a central depot.

3. Delays en route for classification of freight cars are incompatible with quick delivery over long distances. In many cases, short-haul and long-haul freight is now segregated, the long-haul freight being made up in solid trains for "through" or "main track" movement to its destination without stops except for changing engines or car inspection.

4. Short-haul freight often is handled by motor truck and the ultimate outcome will probably be the diversion of most short-haul traffic from rail to road vehicles.

5. Where the traffic density on any railway line falls below a certain magnitude, operation of that line is no longer an economic proposition; and if the traffic offered by the district served by that line can be properly and economically handled by motor truck, its abandonment is indicated. If the traffic has decreased because of diversion to a competing line, consolidation is indicated, with probable abandonment of the lightly loaded line.

6. In most countries where the railways have been constructed under private enterprise, the present systems have been developed by consolidation of smaller systems, either by legislative fiat, as in England, or by gradual absorption of the weaker systems by the stronger, as in the U.S.A. The American railways are still being slowly consolidated into fewer competing systems, and it is at least possible that Government interference will act to hasten this process, resulting in the abandonment of unnecessary mileage, in decreased duplication of rolling stock and personnel, and in reduction of operating expenses, accompanied by sharp increases in traffic density.

When these tendencies are followed to a conclusion, the railways appear in the transportation picture as the principal means by which dense long haul-traffic is handled. With such an organization the general scale of railroad operation, both as regards terminals and the main connecting lines, will be enlarged beyond anything now existing outside of a few instances, and the engineering problems connected therewith will become more pressing as the developments outlined proceed. Leaving out of account the terminal problem, namely, that of providing loading facilities, driveways, approaches, etc., for handling in a few main terminals the freight entering and leaving a large city each day, the main problem will be that of providing rolling stock and motive power to haul a greater concentration of freight over the tracks available.

The traffic capacity of a piece of railway track, expressed as the ton miles per mile of track per annum, is a function of the size of trains, the permissible headway between trains, and the speed of travel. These in turn are dependent on track alignment, gradients, capacity of rolling stock, and the locomotive power available. To give a concrete picture of the influence of these factors, figure 1 depicts the profile and track arrangement of a double-track railway line connecting points A and F, 200 miles apart. With certain stretches of four-track route, at B, C, and E, where freight trains can take the side track to permit overtaking by passenger trains, the most dense disposition of traffic is shown on the accompanying graphic train sheet. The track arrangement permits dispatch of freight and passenger trains at hourly intervals, which means that the maximum traffic this railway can handle is 24 freight and 24 passenger trains per day in each direction.

It is important to note that this is a theoretical figure. In scheduling a heavy freight train there is an element of chance; delays will be encountered en route from a variety of causes. In this connection a study made by the committee on economics of railway operation of the American Railway Engineering Association[1] showed that train movements are seriously interfered with by accidental delays and track limitations when the actual traffic is about 50 per cent of the theoretical capacity.

The following assumptions were used in making up the train sheet of figure 1:

Freight-train trailing load	3,000 tons
Freight-train locomotive	3,000 horsepower
Freight-train maximum speed	40 miles per hour
Passenger-train maximum speed	70 miles per hour
Passenger-train weight	450 tons
Passenger-train locomotive	2,400 horsepower

Using these figures with the traffic density shown on the train sheet, the theoretical traffic-handling capacity of the line is 26,000,000 ton miles per mile of track per annum; 50 per cent of this gives 13,000,000 ton miles per track mile per annum as being the actual limit of the freight-handling capacity of the road. The foregoing figures for train weights and locomotive power rating represent what is attainable with present-day practice, using steam locomotives of conventional design.

While a freight-traffic density of 13,000,000 ton miles per track mile per annum is a high average, it is by no means unheard of and is even exceeded on several American railways. But when coupled with a dense passenger traffic, the problem of keeping the rails clear is likely to become very difficult, which is particularly marked where the termini of the railroad are situated in centers of large population.

Without resorting to a program of rebuilding the railway, there are several ways of relieving congestion and so increasing the traffic-handling capacity of the railroad depicted in figure 1. The most obvious of these are as follows:

1. The weights of freight trains might be increased. If the trailing loads of all the freight trains indicated on figure 1 were doubled, obviously the freight traffic capacity of the railroad also would be doubled, provided train speeds were not reduced.

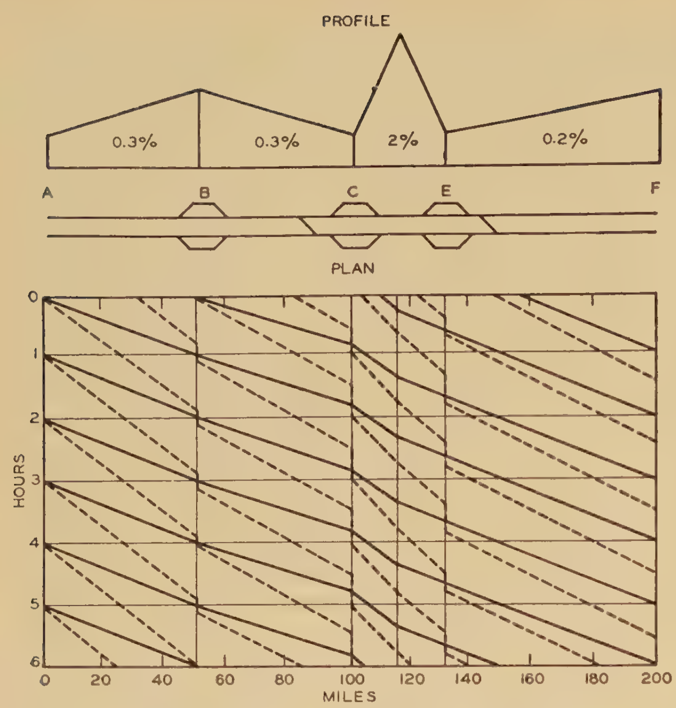

Figure 1. Train sheet showing maximum traffic on two-track railway

Each sloping line is a time/distance chart for a train. Dotted lines indicate freight trains; solid lines passenger trains

2. The freight-train speeds may be increased. If the speed of the freight trains indicated in figure 1 were the same as that of passenger trains, then the headway between trains could be reduced to something determined principally by the length of the signal blocks.

3. The capacity of the rolling stock may be increased. This enters in a very important way into the problem of determining locomotive power, principally because (*a*) the tractive resistance, or drag, of a train made up of heavy large-capacity cars is much less than that of a train of the same weight made up of light small cars, and (*b*) the tare weight of a large-capacity freight car is much less than the tare weight of a small-capacity car in proportion to the load. For example, a goods wagon of eight tons load, as commonly used in England, might have a tare weight of four tons. A 120-ton coal car, as used in the U.S.A. has a tare weight of about 30 tons. The American railways thus are hauling only about half as much dead load per revenue ton as the English railways; and the number of serviceable cars required to handle a given traffic directly affects operating costs. The greater capacity of the rolling stock is a very important reason that freight transport per ton mile in the U.S.A. costs only one-third as much as in England. The trend of past developments, as well as such general considerations as the foregoing, point to a continued increase in the capacity of rolling stock, which permits the net ton miles produced to increase in relation to the gross ton miles.

The increase in speed and weight of trains, as mentioned under the foregoing items 1 and 2, involves an increase in the power output of the locomotives. Every increase in the ton miles produced per train hour, which is an index of the rate at which transportation can be produced with any given equipment, brings up the question of the adequacy of the motive power. If development proceeds along the lines outlined, that is by restricting long-haul traffic to the railways, and by a program of consolidation and abandonment of certain existing lines, thus increasing the traffic density on lines remaining in service, the question of locomotive capacity will be one of pre-eminent importance.

The power output of a locomotive is the product of the tractive effort exerted at the rims of the driving wheels and the velocity of the locomotive. If the tractive effort is in pounds and the velocity in miles per hour, then this product must be divided by 375 to give the locomotive horsepower at the rails.

In the example depicted in figure 1, the freight locomotives were assumed to have a rail horsepower of 3,000 and the trailing loads were assumed to be 3,000 tons. Such trains can move at 38 miles per hour over a gradient of 0.2 per cent using the maximum power of the locomotive.

A Pacific-type passenger engine of 2,400-horsepower capacity with a 500-ton trailing load can traverse this same gradient at 80 miles per hour; and if the headway between trains is 30 minutes, the passenger train will overtake the freight train 46 miles from the terminal. This means that the freight train would have to take to a siding to permit the passenger train to pass after at most 46 miles.

But if the freight-train speed can be increased to 60 miles per hour, then with the same headway between trains the passenger train would not overtake the freight train until a point is reached 120 miles from the terminal. The effect of speeding up the slower trains is thus very beneficial in clearing up the right of way and in permitting a reduction in the time interval between successive trains.

However, to move a 3,000-ton train at 60 miles per hour over a 0.2-per cent grade requires a steam locomotive of about 6,300 horsepower at the rails, and the questions to be answered are: First, can a locomotive of such capacity be built within reasonable limitations of weight and size; and second, can any other type of locomotive, such as Diesel or electric, do the job better?

The power developed by a steam locomotive is a function of the rate at which the fuel is burned in the firebox; therefore, locomotives of larger horsepower rating must be provided with larger fireboxes and heating surfaces, which in turn leads to larger boilers and greater weights for the complete locomotives. It seems to be pretty definitely established that the weight efficiency of conventional steam locomotives of large output, in pounds per horsepower, is not much better than that of locomotives of moderate output.

The traffic-handling capacity of a railway track, and its attendant problems of locomotive power, have been the subject of study for some years by the committee on economics of railway operation of the American Railway Engineering Association.[1] In volume 40 of the *Proceedings* of the AREA[2] are summarized the results of a study of a great number of steam engines and engine types as regards the relation between weight and power rating for modern locomotives. Without here discussing the methods for obtaining the figures given, other than to point out the obvious fact that the locomotive power depends on the size and weight of the boiler and on the firebox grate area, which in turn determine the wheel arrangement and weight on the driving axles, the normal rail horsepower of modern locomotives equipped with all

economizing devices gives specific weights about as follows:

2–8–2 "Mikado" type	188 pounds per horsepower
2–10–4 type	187 pounds per horsepower
4–6–2 "Pacific" passenger type	202 pounds per horsepower

These weights are based on the total weight of engine and tender, and the rail horsepower was estimated by taking the cylinder or indicated horsepower and deducting losses based on the usual 25 pounds per ton on drivers for machine friction. The weight efficiencies given apply to the "normal horsepower", which is defined as being 75 per cent of the maximum or test-stand horsepower. In actual service we cannot count on being able to develop the full test-stand power of a steam locomotive. The maximum power is developed at a firing rate of about 150 pounds of coal per square foot of grate area per hour, but at this rate the over-all thermal efficiency of the locomotive is very low, leading to excessive fuel consumption. In service the usual firing rate is between 50 and 100 pounds per hour per square foot of grate area, depending on gradients and the necessity for "forcing" the locomotive, so that the power output actually developed is between 50 and 80 per cent of the maximum possible. The result of these various factors is that the weight efficiency on which we can count is rarely better than 200 pounds of total locomotive weight per rail horsepower developed.

On this basis a locomotive of 6,300 horsepower would weigh 630 tons, of which with normal modern designs 40 per cent, or 252 tons, would be on the driving wheels. A 2–10–4-type locomotive of 6,300-horsepower capacity would then have a driving-axle load of 100,800 pounds per axle. Such an axle weight as this would be intolerable from the standpoint of bridge-structure and track stresses. If we decide to go to an articulated type of locomotive, say having eight driving axles in two groups of four, the axle loading is reduced to 63,000 pounds per driving axle. This is within the permissible axle loading for most American railways, and if bridge structures have sufficient strength to take the total locomotive weight, the vertical track stresses perhaps would not be excessive. If at 60 miles per hour the driving wheels are limited by considerations of dynamic augment to 300 rpm, the required driving-wheel diameter is 67 inches and the rigid wheel base 18 feet—6 inches. When the lateral restraint in the articulation hinge is taken into account, it cannot be said offhand that such a long rigid wheel base will not introduce lateral track stresses of undesirable magnitude. But other difficulties following an adoption of locomotives of greatly increased rating would be that of providing engine-house facilities, turntables, etc., for engines of much greater length than any now used.

Any program of railway reorganization resulting in such traffic density that it would become necessary to move 3,000-ton or heavier freight trains at 60 miles an hour thus would bring the motive-power problem very prominently forward, and its economic as well as physical aspect would prompt consideration of a radical change in the type of tractive power to be used.

It does not seem likely that there will be in the near future any noteworthy improvement in the performance or weight efficiency of steam locomotives. The thermal efficiency of a steam engine theoretically can be improved by increasing the steam pressure and temperature and by superheating; but despite what is done in these respects, the fundamental fact remains that the principal cause of the inefficiency of a steam locomotive lies in imperfect combustion. Admittedly it is possible to reduce the firing rate in a locomotive firebox, and at the same time to raise the boiler pressure and steam superheat to the point where the over-all thermal efficiency might reach, say, 20 per cent; but the large firebox necessary to give the required evaporation at a low firing rate would entail such a great increase in the weight of the engine that the over-all weight efficiency would be no better than it is with conventional designs.

The problem of providing locomotives of 6,000 horsepower and over therefore must be solved by some means other than that of increasing the size of the conventional steam engine. The most promising rail tractor in this respect is the electric locomotive. The electric locomotive is not a prime mover; it is a transformer of energy furnished to it from a generating station situated at some distant point, and hence its inherent limitations as a rail tractor are not fixed by any considerations of combustion or thermal efficiency. The power it can develop is fixed by the characteristics of the electric motors by which the driving wheels are propelled, and the characteristics of the whole locomotive therefore are determined by the type of motor used.[3]

As a result of significant improvements in the single-phase series traction motor during the past ten years, going hand in hand with progress in methods of solving the difficult circuit-analysis problems met in a-c traction,[4,5,6] there has been in the United States during this period a great extension in the use of single-phase alternating current for heavy-traction electrification; for this reason the following discussion, looking to the possibilities of moving heavy freight trains at high speeds by

Westinghouse

electric locomotives, is confined to the single-phase a-c system using series traction motors. For the time being it may be taken as axiomatic that the overhead contact line from which the electric locomotive draws energy has infinite capacity and that it is possible to install a step-down transformer on the locomotive of enough capacity to handle whatever power is required by the traction motors. With these assumptions the limitations of the electric locomotive coincide with the limitations of the motors. The output of a series motor is limited by two factors, (1) commutation and (2) heating, with the additional mechanical limitation of (3) the peripheral speed of armature and commutator.

Taking account of these limitations, it has been shown in a previous paper[3] that the starting tractive effort at the rails exerted by a single-phase traction motor is given by the formula

$$TE = 5{,}000 \frac{pl}{\text{mph max}} \text{ pounds at 25 cycles per second}$$

In this expression

p is the number of poles on the motor
l is the active length of the commutator in inches

Thus for a 12-pole motor having an active commutator length of 9 inches and geared for a maximum speed of 70 miles per hour, the starting tractive effort would be 7,700 pounds. Using two motors per driving axle and assuming 25-per cent adhesion, the required weight per driving axle is then 62,000 pounds. Using six driving axles and a guiding truck at each end of the locomotive, with a 2C+C2 wheel arrangement, the total locomotive weight would be about 280 tons; and we know from previous designs that a locomotive of this type can be built to give one horsepower of continuous rating for each 100 pounds of weight (about 40 pounds per horsepower for the electrical equipment, and about 60 pounds for the mechanical parts). Thus the example indicates that we can build a high-speed freight locomotive of conventional wheel arrangement and conservative axle loads to give a continuous rating of at least 5,600 horsepower, or 933 horsepower per axle. This rating is not excessive, since three-axle locomotives have been built and are in service with 1,250 horsepower per axle.

It is necessary to point out that the electric locomotive is not a constant-output machine. The speed–tractive effort curve for an electric locomotive has a much steeper slope than that for a steam locomotive of the same nominal rating. If we denote the tractive effort by p and the train velocity by v, then the speed–tractive effort curve of the steam locomotive is given by $pv = \text{constant}$. The electric locomotive has a characteristic curve for which the equation is pretty closely $pv^{2.8} = \text{constant}$. The continuous rating of an electric locomotive is that continuously maintained power output at the rails at which the temperature rise of the motors does not exceed that specified in the Standards of the American Institute of Electrical Engineers. The effect of the steeper slope of the characteristic curve of the electric locomotive is to make the locomotive assume an overload when its speed is reduced by adverse gradients. Thus on a gradient the rail horsepower output of an electric locomotive rated at 5,600 horsepower will be greater than 5,600 horsepower, and the electric locomotive is able to maintain a much better schedule speed than a steam locomotive of the same rating.

It has been mentioned that the specific weight of an electric locomotive of modern design is of the order of 100 pounds per horsepower, as compared with the 200 pounds per horsepower of the steam locomotive. The effect of this is to reduce the dead weight of the equipment to be hauled and to permit a reduction in the rating of the electric locomotive as compared with the steam locomotive.

To see how this comes about, we may take the same example as before, namely, that of a 3,000-ton train moving at 60 miles per hour up a 0.2-per cent grade. To generalize, let W tons be the weight of the train and w tons the weight of the locomotive. Then using average figures for train resistance:

Train resistance $= 6W + 10w$
Grade resistance $= 4(W + w)$
Total resistance $R = 10W + 14w$

Also

$$HP = \frac{Rv}{375}$$

and

$$w = \frac{HP}{10} \text{ (steam locomotive)}$$

or

$$w = \frac{HP}{20} \text{ (electric locomotive)}$$

Substituting $W = 3{,}000$, and solving for w and HP, we find the required steam-locomotive rail horsepower is 6,200, the weight being 620 tons. For the electric locomotive the required horsepower is 5,400, the weight being 270 tons.

This striking contrast, of a 270-ton electric locomotive being able to do the same work as a 620-ton steam locomotive, seems to indicate clearly the method by which the motive-power problem will be solved as railway-traffic density becomes so concentrated as to require more rapid movement of freight over the lines. But the use of electric locomotives brings with it the attendant problems of transmission and distribution of electric energy to the trains.

The dimensions and configuration of the transmission and distribution system of an electrified railway are, of course, dependent on the loads the system has to supply; they are also dependent on the voltage and frequency of the contact line and supply system. This question was the subject of a paper by McGee and Harder[5] whose investigations showed that it is easily possible, with a contact line voltage of 11,000, to provide enough capacity in the distribution network to handle traffic up to the limit of the tracks available. But since a large capital investment is required to provide a distribution system for an electric railway, there remains the engineering problem of so designing the transmission and contact lines and substations that the cost will be as low as possible.

A large part of the cost of the distribution system is chargeable to the step-down-transformer substations, and economical construction requires therefore that the substation spacing be as great as possible. If a given load is to be supplied with a given voltage drop between the substation bus bar and the load, an increase in distance between substations makes it imperative that the contact-line voltage be increased. In the United States the standard line voltage has hitherto been 11,000 volts for single-phase systems, but some electrified railways have provision for a change-over to 22,000 volts. In a general scheme of railway electrification, it now appears that even this voltage might be insufficient, and it is at least possible that a contact line potential of 50,000 volts will be considered.

In this discussion of electric traction, attention has focused on its engineering aspects. It is not possible in a reasonable space to analyze the economic features of electric traction as compared with steam, but it might be well to state in a broad fashion the general economic factors that lead to a decision for or against electric operation of a railway. In electric traction as in any other form of transportation the cost of producing a ton mile is made up of the operating cost and a proportion of the fixed charges on the investment. Since it may cost some $35,000 per track mile to equip a railway for electric operation exclusive of rolling stock, it is evident that electric traction will greatly increase the fixed charges on the property. Hence, unless a great increase in traffic density accompanies the electrification, there must be a considerable reduction in operating cost per ton mile produced. This reduction in operating cost always is obtained, arising principally from the following:

1. The number of electric locomotives required to handle a given traffic is always less than the number of steam locomotives needed for the same traffic. Since an electric locomotive (per horsepower at the rail) costs about the same as a steam locomotive, the investment in electric rolling stock is moderate. The reduced number of locomotives results in a great reduction in engine-house and maintenance costs.

2. The maintenance cost per horsepower mile of an electric locomotive is very much less than that of a steam locomotive. In nearly every case where electric traction has been applied, the cost of maintaining electric locomotives has proved to be about half that of the pre-existing steam locomotives.

3. The "availability", or the percentage of the total time during which electric locomotives are available for service, usually exceeds 90 per cent, as compared with at best 50 per cent for steam locomotives. This is why a given traffic density can be handled with far fewer locomotives than when steam locomotives are used, and the result is a great reduction in locomotive expense for such services as hostling.

4. Because an electric locomotive will assume an overload when its speed is reduced by adverse gradients and will develop up to twice its normal power output during acceleration, a given tonnage can be moved over the rails at much better schedule speed than can be achieved with steam or other constant-horsepower locomotives. This results in a reduction in the number of train-hours, with a consequent saving in crew expense.

5. With electric traction, there is a considerable item of expense in the maintenance of overhead transmission and distribution lines and substations. It usually happens, however, that this expense is of the same order of magnitude as that of maintaining fuel and water facilities required with steam traction.

6. It is a popular belief that because of the high thermal efficiency of modern electric generating stations, the cost of power for electric traction is much less than the cost of fuel required for steam traction. This, however, is not the case where coal is cheap. In the eastern part of the United States, for example, the cost of electricity per ton mile moved by electric traction is of the same order of magnitude as the cost of coal per ton mile moved with steam locomotives. This is due to the effect of the demand clause in all power contracts, by which the cost per kilowatt-hour is devoted in part to carrying the fixed charges on the electric-power equipment.

The result of these considerations, particularly items 2 and 4 is that electric traction always shows an operating saving when compared with steam traction. A decision for or against electrification is therefore dependent on the economic consideration of capital cost. To express this algebraically, let

C_s = the operating cost per ton mile with steam traction
C_e = the operating cost per ton mile with electric traction
F = the total annual fixed charges on the investment required for electrification
D = the total ton miles hauled per annum

Then electrification is economically justified when

$$C_s > F/D + C_e \tag{1}$$

In any well-planned electrification scheme C_e always will be less than C_s, so that the deciding factor for or against electric operation will be the quotient F/D. This should be as small as possible, which can be attained by keeping the cost of the electrification to a minimum or by increasing the traffic density. The cost of equipping a railway for electric operation is dependent principally on the engineering skill brought to bear on the physical problems involved; and as engineering science progresses, improved methods perhaps will tend to lower the first costs of electrifying, although these improved methods often are adapted to increase the operating reliability of the system at some sacrifice in cost.

The picture of the rail-transport system as developed herein has pointed to the desirability of developing the railways into a tool for the concentrated mass production of transportation by consolidation and reorganization. As this development progresses the traffic density on the favored lines will increase, perhaps until the quantity F/D in equation 1 is vanishingly small. In such a case the physical advantages of using electric motive power undoubtedly will dictate a policy of railway electrification on a scale sufficiently broad to exploit its real advantages. At any rate the considerations outlined will warrant a careful study of the motive-power problem.

In this discussion of motive power for rail traction no mention has been made of the Diesel-electric locomotive. It is frequently thought that the use of electric traction motors confers on these locomotives all the merits of the electric locomotive. Such, however, is not the case. Obviously the rail output of a Diesel-electric locomotive is fixed by the rating of the Diesel engine, which has a definitely limited output. On the other hand, the power available for propelling an electric locomotive is for practical purposes infinite, and the rail power output is limited principally by the commutation and heating of the traction motors, which with modern locomotives

allows them to develop 25-per cent adhesion up to speeds of 50 miles an hour. The weight efficiency of the Diesel locomotive is about half that of the electric, and the first cost is about twice as great. Therefore, it does not seem that the Diesel locomotive offers any special advantages over steam locomotives for the handling of dense main-line traffic. The cleanliness of the Diesel-electric engine favors its use for the hauling of de luxe passenger trains, and it has been widely applied in this field. The Diesel locomotive also is being used increasingly in switching service, where its high degree of availability and low stand-by losses show up very favorably against the steam switching engine. But for very heavy main-line traffic the choice of locomotives probably always will be between the steam and the electric, with electric traction showing pronounced advantages when the traffic density exceeds the economic limit given by equation 1.

This article has outlined some of the problems that are arising in the railway field, and has discussed in more detail the question of motive power. In a reasonable space it is impossible to consider all the engineering problems that are most pressing today as a result of the increase in train weights and speeds now used in an attempt to retain or regain business in the face of competition. But some of these developments are so important that they cannot be overlooked in any review of modern rail transport, and the following list outlines a few of the most outstanding:

1. *Reduction of Tare Weight of Rolling Stock.* Modern freight rolling stock is of all-steel construction, using high-strength special alloys to give a greater proportion of load to tare. A more spectacular development is that of the stainless-steel and aluminum-alloy passenger rolling stock, resulting in equipment weighing about half that of the former designs of all-steel passenger cars.[7]

2. *Strength of Track.*[8] For many years past an intense study has been made of rail stresses, in an attempt to eliminate the cause of transverse rail fissures and broken rails. The battering of rail ends under heavy wheel loads also has come under this study, and has led to the development of the continuous welded track and to experiments with concrete subgrade. As another part of this development there have been radical changes in the design of steam-locomotive driving wheels and reciprocating parts, to reduce the pounding of drivers caused by dynamic augment at high speeds. Incidentally, it may be pointed out here that dynamic augment is absent with electric or Diesel-electric drive.

3. *Train Control.* There is a pronounced and rapid development toward the governing of all train movements by signal indication. While all passenger and many freight trains move under official printed time table authority, no train can be permitted to occupy a block against a restrictive signal indication. It is therefore imperative to furnish reliable track circuit and relay equipment for displaying proper signals, and for informing the dispatcher as to the condition of any piece of track. A recent and expanding development in this connection is the "centralized traffic control", whereby a dispatcher is given control and indication over the territory under his jurisdiction, all switching operations being performed remotely by an electric control system similar to the "supervisory control" used in power systems.

4. *Speed.* In recognition of the fact that schedule speeds are affected by deceleration to the same extent as by acceleration, and because the use of higher speeds with modern equipment has involved questions of the adequacy of train-stopping distances in relation to signal spacing, there have been important developments in braking equipment. One of the most radical has been a means of automatically varying the braking force as a function of train speed, to take account of the variation in the coefficient of friction between brake shoes and wheels with variations in speed.

5. *Passenger equipment.* To the public, the most striking railway development of recent years has been the improvement of passenger equipment as regards speed and comfort. The most rapidly spreading improvement in this regard has been the use of air-conditioning apparatus, whereby the interior air of passenger cars is maintained at a predetermined state of temperature and cleanliness regardless of outdoor conditions. The general appearance and design of modern passenger trains also has undergone radical change at the hands of professional industrial designers engaged by the railroads and manufacturers to aid in the improvement of rolling stock. The reduction in weight of passenger trains already has been discussed.

Parallel with these engineering developments, noteworthy economic experiments in rail transport are under way. The greatest of these is undoubtedly the electrification of the Pennsylvania Railroad.[9,10] The Pennsylvania on its New York-to-Washington line handles perhaps the heaviest mixed traffic density in the world, and is the first instance of electric traction having been adopted on a scale broad enough to exploit its real advantages and to look on electric traction primarily as a tool for efficient transport rather than as a means of solving a specific problem in motive-power application.

All these developments seem to point to the future organization of the railways as a machine for the rapid and efficient production of traffic units—ton miles or passenger miles. The railway system shows up most favorably when it has to handle very dense traffic over long distances, or, in other words, when it can manufacture transportation on a mass-production basis. The interpretation of recent developments in the physical equipment of the railways as steps toward such an organization may be incorrect, but the fact remains that the railways cannot survive as an economic unit unless the traffic density has a sufficiently high average to pay the operating expenses and fixed charges. It seems to the author that increases in traffic density and reductions in operating expenses can best be attained by some program of co-ordination and consolidation such as outlined earlier in this article. If such a program is carried out, the engineering problems discussed here will be of very real importance.

REFERENCES

1. Method of Increasing the Traffic Capacity of a Railway. American Railway Engineering Association *Proceedings*, volume 32, 1931, page 643.

2. Report of Committee on Economics of Railway Operation. American Railway Engineering Association *Proceedings*, volume 40, 1939, page 83.

3. Electrification of Railways, A. M. Wright. *Journal* of the Institution of Electrical Engineers (London), volume 77, 1935, pages 826–44.

4. Wave Propagation in Overhead Wires With Ground Return, J. R. Carson. *Bell System Technical Journal*, volume 5, 1926, pages 539–54.

5. Power Supply for Main-Line Railway Contact Systems, P. A. McGee and E. L. Harder. AIEE Transactions, volume 52, 1933, pages 364–75.

6. Regulation and Inductive Effects in Single-Phase Railway Circuits, A. W. Copley. *Electric Journal*, volume 17, 1920, pages 326–38.

7. Design of Light-Weight Trains, R. Eksergian. *Transactions* of the American Society of Mechanical Engineers, volume 56, 1934, pages 667–701.

8. Progress Reports of the Joint Investigation of Fissures in Railroad Rails. American Railway Engineering Association *Proceedings*, volumes 36–40, 1935–39.

9. Single-Phase Electrification on the Pennsylvania Railroad, H. C. Griffith. *Journal* of the Institution of Electrical Engineers, volume 81, 1937, page 91.

10. Evolution From Steam to Electric Traction. *Railway Age*, volume 107, 1939, pages 440–3; 446, 449.

Selecting Distribution-Transformer Size

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To use the current American Standards Association recommendations* for loading distribution transformers, the fluctuating daily load curve of a distribution transformer must be converted into thermally equivalent rectangular form. This article presents a method by which the conversion may be made and the recommendations applied.

IN GENERAL, transformers are designed for a stated temperature rise when operated continuously at rated output. However, load requirements under actual operating conditions are variable, so that relatively few transformers are required to operate under steady load conditions. This is especially true of the smaller pole-type transformers, whose daily loads fluctuate over a wide range, with one, two, or three peaks, depending on the type of connected load.

It is recognized that higher-than-rated load may be permitted for short durations. There are two main reasons for this. First, the heat-storage characteristics of the materials in a transformer prevent it from immediately reaching the ultimate temperature on a suddenly applied load.[8] Second, insulation deterioration is a function of both time and temperature—the shorter the duration of the load, the higher the temperature can be to produce the degree of aging obtained at longer durations and lower temperature.[7,14]

Various methods have been used to determine the economic loading of distribution transformers, ranging from a simple but arbitrary limit of peak load (such as 150 per cent of rating) to the most elaborate calculations of time-temperature curves which are tediously converted into equivalent life through the use of insulation-aging data.[17]

While the latter is the most scientific method, its accuracy is limited by the accuracy with which the factors are known, and in many cases its use is not justifiable because of the variation of uncontrollable factors. The essential factors in this method of transformer-size determination are:

1. Temperature-gradient data of the transformer. It is difficult to obtain accurate temperature-gradient data for even one design, whereas there may be many designs of different makes and dates of manufacture to be considered. When one attempts to make this type of calculation on all the designs on a given system, the task becomes formidable.

2. Insulation-aging data. The available insulation-aging data are not very consistent. Nichols,[14] for example, gives the life of insulation at 105 degrees centigrade as $1^1/_3$ years, while Montsinger[7] gives the life as 7 years at this temperature. Also the number of degrees centigrade increase in temperature required to double the rate of insulation deterioration varies approximately 20 per cent (i.e., from 8 to 10 degrees centigrade).

3. Load cycle. A specific load cycle will produce a specific aging effect. Since it rarely happens that any two load cycles on a given installation are identical, in the interest of minimum calculating time it is the usual practice to choose one or possibly a few "typical" daily load cycles for the time-temperature-aging calculations. Therefore, in general, it represents a compromise at best.

There are many other factors, such as rate of load growth, intervals between consecutive transformer sizes, and effect of ambient temperature, whose large variations neutralize the value of any attempt to make precise time-temperature-aging calculations.

The need therefore is evident for a method of transformer-size determination that tends toward the simplicity of the arbitrary peak-load-limit method but recognizes the thermal characteristics of transformers of various designs and the aging characteristics of insulation involved in the tedious time-temperature-aging method.

In this article a method is proposed whereby the fluctuations of a daily load cycle can be converted into a thermally equivalent rectangular load cycle, thus obtaining the simplicity of the arbitrary peak-load method. Then, by reference to curves based on the American Standards Association proposals for transformer loading,[1] the aging characteristics of insulation as well as the thermal characteristics of transformers of various designs and manufacture are considered. Thus the required distribution-transformer size can be determined quickly and with accuracy commensurate with its application. Recommendations for ambient temperature correction are also given.

Although this article is devoted primarily to the thermal aspects of transformer application, the important factor of voltage regulation must always be borne in mind. While this may not be serious for moderate overloads, it becomes increasingly important at the higher loads which may be permitted from the thermal viewpoint for short durations and low ambient temperatures. It will often be found in application studies that regulation rather than thermal consideration limits the load which may be applied to a transformer.

Like regulation, provision for load growth is also a factor peculiar to each distribution system and therefore must be considered by the individual user for the particular system involved.

Essential substance of AIEE paper 39-171, presented at the Middle Eastern District meeting, Scranton, Pa., October 11–13, 1939.

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* The American Standards Association issued in March 1940, "for trial and criticism", proposed American standards for Transformers, Regulators, and Reactors, and proposed American recommended practices regarding Test Code for Transformers, Regulators, and Reactors, and Guides for Operation of Transformers. The publication was prepared by the sectional committee on transformers, C57, of which V. M. Montsinger (A'14, F'29) is chairman, and "contains data gathered from many sources, notably the established standards of the AIEE and of the National Electrical Manufacturers' Association." Preliminary publication of some of the material was made in ELECTRICAL ENGINEERING, January 1937 (see reference 1).

8. For all numbered references, see list at end of article.

ASA "GUIDE FOR OPERATION OF TRANSFORMERS"

The ASA proposed loading guide[1] incorporates curves for the short-time overloading of distribution transformers 100 kva and smaller, below 15,000 volts, and of network transformers 500 kva and smaller.

The loading guide, reproduced in figure 1, consists of two distinct curves, *A* and *B*. Curve *A*, for durations below five minutes, assumes the load to be emergency, such as a short circuit, and to follow full load. Curve *B*, for durations of five minutes and above, assumes the load to be recurrent, such as the daily load cycle, and to follow no-load or excitation only. It will be observed that curves *A* and *B* permit the same overload at the five-minute point, although the assumed loading conditions are different. That this is reasonable may be more obvious when it is realized that more severe loading may be permitted for emergency or infrequent conditions than for premeditated or recurrent loading conditions. Thus, for recurrent conditions the severity of the loading is reduced by changing the starting condition to no-load instead of full load.

Recurrent Loads Following Partial Load. For those applications where the recurrent load is to follow a partial load which has been on long enough to establish steady state conditions, the allowable load is readily determined from curve *B* by interpolation, as explained in a paper entitled "Overloading of Power Transformers," by V. M. Montsinger and W. M. Dann.[11]

Following this method of interpolation, the group of dashed curves *C*, *D*, *E*, and *F*, shown in figure 1, for various initial continuous load conditions were obtained.

Since the daily load requirements usually determine the transformer size, this article will be confined to recurrent loading conditions and therefore refers to curves *B*, *C*, *D*, *E*, and *F*, as the base loading curves.

These curves indicate the amount of overload a transformer can safely carry under various combinations of continous initial load and peak duration. For example, figure 1 indicates:

160 per cent load is permitted for one hour, following continuous no-load (curve *B*)

150 per cent load is permitted for 17 minutes, following continuous 75 per cent load (curve *E*)

120 per cent load is permitted for three hours, following continuous 60 per cent load (curve *D*)

Elementary Daily Load Cycles. The use of the curves in figure 1 necessitates the assumption of rectangular load cycles. If "kilovolt-ampere" is substituted for "per cent" in the second and third examples given above, the cycles shown in figure 2 are obtained.

Load cycle *A* consists of 75 kva from 7 a.m. to 7 p.m., followed by a peak load of 150 kva for the 17-minute period from 7 to 7:17 p.m. Load cycle *B* consists of 60 kva from 6 a.m. to 6 p.m., followed by a peak load of 120 kva for the three-hour period from 6 to 9 p.m.

From the direct substitution of kilovolt-ampere for per cent in these cycles, it is readily deduced that a 100-kva transformer is the proper size to serve either of these load cycles. However, there are many cases where the proper rating is not so obvious.

Transformer-Rating-Factor Curves. In order to simplify the solution of this type of problem, the required transformer rating and the initial load will be expressed in terms of the peak load.

In the case of cycle *A* in figure 2, the required transformer rating, in terms of the peak load, is $100/150=0.67$, and the initial load is 50 per cent of the peak load (that is, $75/150\times100$).

In cycle *B*, the required transformer rating is $100/120=0.83$, and the initial load is 50 per cent of the peak load (that is, $60/120\times100$).

These two load cycles represent two combinations of transformer ratings and peak duration for 50 per cent initial load, expressed in terms of the peak load. These two combinations, namely: 0.67 for 17 minutes (cycle *A*) and 0.83 for three hours (cycle *B*) constitute two points on the 50 per cent initial-load curve in figure 3. Other combinations of load and time may be chosen to obtain additional points for the 50 per cent initial load curve as well as for curves for other values of initial load.

The horizontal scale of figure 3 is the duration of the peak load and the vertical scale is simply the required transformer rating expressed in terms of the peak-load value or what is hereafter termed the transformer-rating factor.

Therefore, it may be seen that any base loading curves of the form indicated in figure 1 may be expressed in terms of peak load and duration. The result is the family of curves shown in figure 3.

CONVERSION INTO SIMPLE EQUIVALENT RECTANGULAR CYCLE

The ordinary distribution daily load cycle is not generally so elementary as the simple rectangular cycles illustrated in figure 2, but more often looks like the cycle in figure 4. It consists of load fluctuations throughout the day, with one period when the load builds up to a value considerably greater than that reached at any other time. This maximum peak is generally not reached or passed suddenly but builds up and falls off more or less gradually.

Therefore, before the curves in figure 3 can be used advantageously, the actual fluctuating load cycle must be reduced to a thermally equivalent simple rectangular load cycle which consists of an initial continuous load followed immediately by the peak load of a given duration. To do this the daily load cycle must be considered in two steps. First, the fluctuating portion of the load cycle previous to the peak must be converted into an equivalent initial continuous load. Second, the major part of the irregular peak must be converted into an equivalent rectangular peak load of a given duration.

EQUIVALENT LOADS

The basis of the equivalent load method, briefly, is this. A transformer supplying a fluctuating load generates a fluctuating loss, but because of the heat-storage characteristics, or "thermal inertia", of the materials in the transformer, the effect over a period of time is about the same as if an intermediate load were held constant for that period. That load, then, which causes loss to be generated at the same rate as the average rate caused by the fluctuating load is called the equivalent load.

The equivalent load for any portion of a daily load cycle may be expressed by the equation

$$\text{Equivalent load or rms value} = \sqrt{\frac{L_1^2 t_1 + L_2^2 t_2 + \ldots L_n^2 t_n}{t_1 + t_2 + \ldots t_n}} \qquad (1)$$

where L_1, L_2, etc., are the various load steps expressed in per cent, per unit, or in actual kilovolt-ampere or current, and t_1, t_2, etc., represent the durations of these loads, respectively.

Equivalent (RMS) Initial Load. Since the average distribution transformer under constant load conditions attains ultimate temperature rise in approximately 12 hours and since the load conditions previous to this time do not affect the ultimate temperature rise, it follows that the rms load obtained by equation 1 over a period of 12 hours previous to a peak may be considered as the equivalent initial continuous load.

Equivalent (RMS) Rectangular Peak Load. The equivalent rectangular peak of an ordinary load cycle is simply the rms load obtained by equation 1 for the limited period over which the major part of the actual irregular peak seems to exist. It will be observed that the estimated duration of the peak has considerable influence on the rms peak value. If the duration is overestimated, the rms peak value will be considerably lower than the actual peak demand of the cycle.

Because the equivalent formula (equation 1) is based entirely on the effect of the load on the oil-temperature rise, a sharp increase in load for a short duration will not be immediately reflected in the temperature of the oil. However, the temperature gradient of the winding over the oil will respond relatively quickly to rapid changes in load. For this reason it is suggested that the load cycle, and particularly the loads in the vicinity of the peak, be considered in one-half hour demand blocks, as this period is about the time required for the temperature gradient of the winding over the oil to become constant.

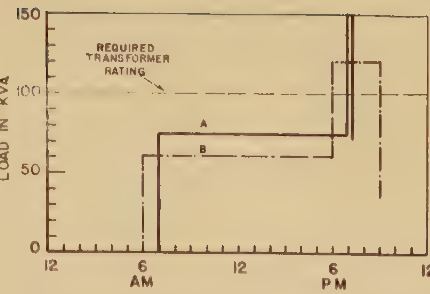


Figure 2. Elementary daily load cycles safely served by a 100-kva transformer

Also, in order further to safeguard against possible severe overheating of the transformer windings due to short-time maximum demands which may greatly exceed the rms peak, it is recommended that the choice of duration of the rms peak be such that the value of the rms peak load will not be less than 90 per cent of the integrated one-half hour maximum demand.

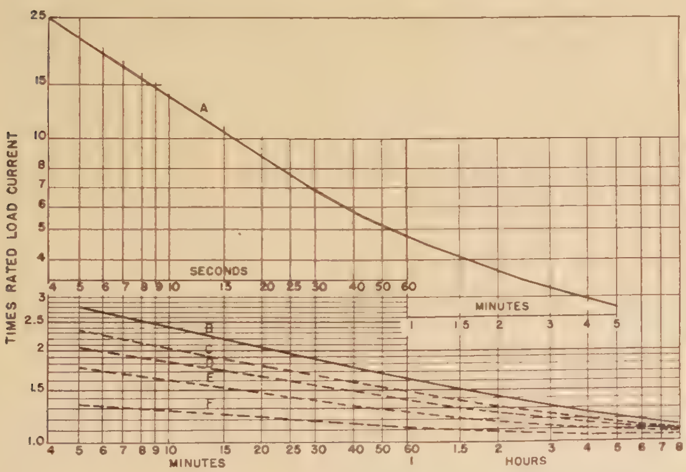


Figure 1. Short-time overloads for self-cooled oil-immersed (55 degrees centigrade) distribution transformers for 30 degrees centigrade ambient temperature

Curve	Overload Condition	Initial Load
A	Emergency	Full load
B	Recurrent	No load
C	Recurrent	50 per cent
D	Recurrent	60 per cent
E	Recurrent	75 per cent
F	Recurrent	90 per cent

APPLICATION OF EQUIVALENT RECTANGULAR LOAD METHOD

In order to illustrate the application of the equivalent rectangular load method for selection of distribution transformer size as determined by load cycle requirements, two typical daily load cycles, representing different service requirements, will be used as examples.

Load Cycle With One Major Peak. The load cycle shown in figure 4 represents a typical daily load cycle for a service supplying ranges and lighting, and has been replotted as a percentage of the integrated one-half hour maximum demand. This method applies equally well to load curves plotted in actual kilovolt-amperes but there are certain advantages in plotting on a percentage basis, particularly in that it permits direct comparison of similarly shaped load curves and often will eliminate much calculation by permitting determination of transformer rating by inspection.

The load is seen to fluctuate quite widely for the period between 12 midnight and 4:30 p.m. At 4:30 p.m. there is, however, a distinct increase in load which, it may be observed, constitutes the beginning of the peak of the cycle.

The major portion of the peak appears to occur during the period from 4:30 to 6:30 p.m. or, in other words, for a duration of two hours. The equivalent rectangular peak then for this period, determined by equation 1, is 91 per cent of the integrated one-half hour maximum demand.

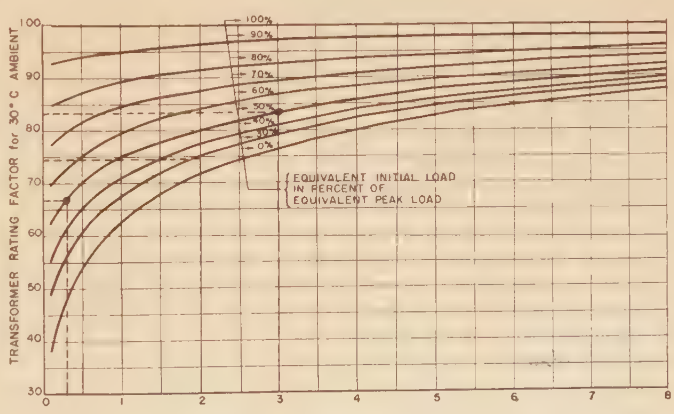


Figure 3. Transformer-rating factor as a function of equivalent rectangular peak duration and equivalent initial load

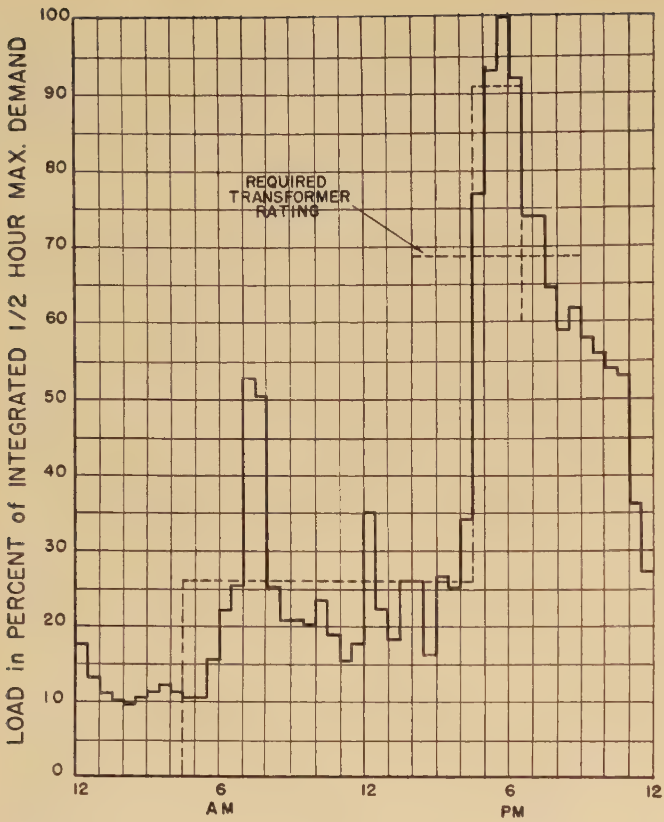


Figure 4. Typical daily load cycle with one major peak

The equivalent initial load is the rms value of the loads for the 12-hour period immediately preceding the equivalent rectangular peak, or, in other words, for the period from 4:30 a.m. to 4:30 p.m. and, for the illustration, results in 26 per cent of the integrated half-hour maximum demand.

The load cycle in figure 4 may now be expressed by an equivalent rectangular load cycle (indicated by the dashed lines) of 26 per cent initial load from 4:30 a.m. to 4:30 p.m. followed by an overload which rises immediately to 91 per cent of the one-half hour maximum demand where it remains for the two-hour period from 4:30 to 6:30 p.m., then drops immediately to a relatively low value.

Estimated Transformer Rating. The next step is to ascertain the transformer rating required to serve the newly determined equivalent rectangular load cycle. This may be accomplished by reference to the curves in figure 3, in which the ordinate of the curves is the transformer-rating factor for 30 degrees centigrade ambient.

Several curves are shown in figure 3 for various equivalent initial load conditions, expressed in per cent of the equivalent or rms peak load. The equivalent initial load in the foregoing example, expressed in per cent of the rms peak load, is $26/91 \times 100 = 28.6$ per cent.

To obtain the transformer-rating factor start at the two-hour peak duration on the horizontal scale in figure 3 and follow the line vertically until it intersects the interpolated "equivalent initial load" curve of 28.6 per cent. Proceed horizontally to the scale at the left from which transformer rating factor of 0.745 is obtained. Multiplying the rms peak of 91 per cent by 0.745 results in an estimated transformer rating of 68 per cent of the half-hour maximum demand.

It should be observed that no consideration has been given to the loads from 6:30 p.m. until midnight. This period may be ignored, provided the load values immediately following the rms peak do not materially exceed the estimated transformer rating. In this load curve the load (74 per cent) for the period from 6:30 to 7:30 p.m. exceeds the estimated transformer rating of 68 per cent. The simple expedient is to increase the estimated duration of the rms load step, but it has been found by experience that if the rms value of loads immediately following but not included in the rms peak is not in excess of 10 per cent over the estimated transformer rating, they may be ignored. In this case, the load immediately following the peak is only $(74/68 = 1.09)$ times the estimated rating.

That this approximation is reasonable may be seen from the continuation of this problem. Following the suggestion to increase the estimated duration of the equivalent peak to three hours to include the load step of 74 per cent (from 6:30 to 7:30 p.m.) results in a rms peak of 85.5 per cent. Since, as has already been recommended, the rms peak should not be less than 90 per cent of the half-hour maximum demand, it is only proper (but conservative) to assume that the rms peak for the three-hour period is 90 per cent.

From figure 3, the transformer-rating factor corresponding to an equivalent initial load of $(26/90 \times 100 = 28.9$ per cent) and peak duration of three hours becomes 0.79, resulting in an estimated transformer rating of 71 per cent of the one-half hour maximum demand, which is only a 4.5 per cent increase over the original estimated transformer rating of 68 per cent.

Load Cycle With Two Major Peaks. It frequently happens that there are two or more major peaks in a load cycle, depending upon the type of connected load, but it often

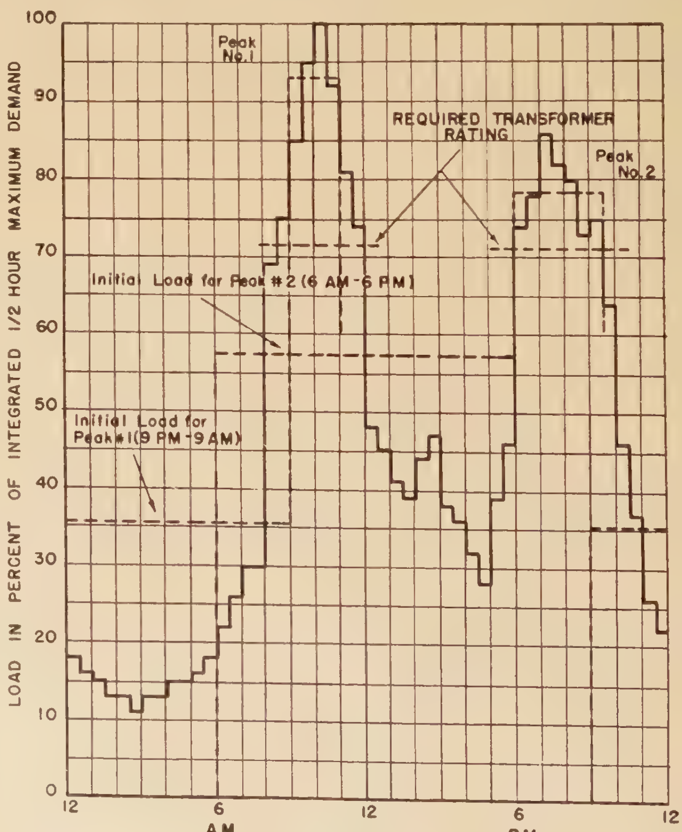


Figure 5. Typical daily load cycle with two major peaks

may be determined by inspection which peak is likely to be the most severe. For instance, if three peaks approximately equal in magnitude occur at say four-hour intervals, the last is definitely the most severe, as the previous two have been contributing to the initial load value. However, when it is not obvious which peak is most severe, it may be necessary to determine the rating required for each.

The load cycle shown in figure 5 for a service supplying lighting, ranges, and refrigerators consists of two major peaks. One, designated as peak 1, occurs at 9–11 a.m. and the other, peak 2, about seven hours later, at 6–9:30 p.m.

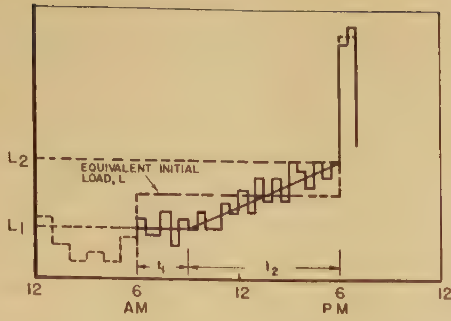
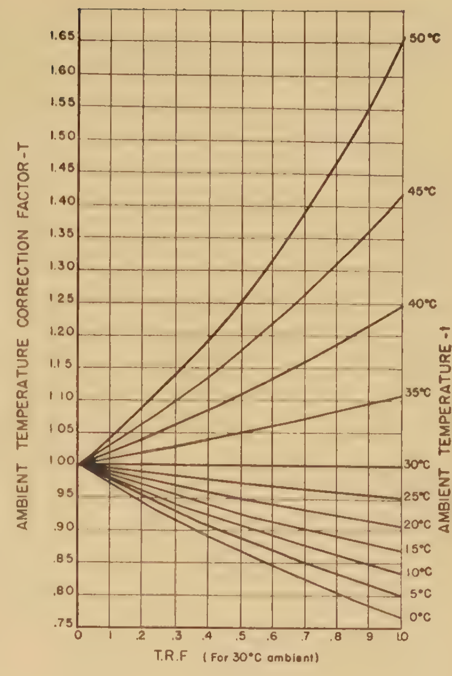


Figure 6. Daily load cycles, such as the one shown here, may be approximated by straight lines with reasonable accuracy (see equation 2)

Figure 7 (right). Ambient-temperature correction factor curves



Following the method previously outlined, the following values may be tabulated, considering peak 1 as the more severe:

1. Rms value of peak 1 (9–11 a.m.) = 93 per cent of maximum demand
2. Rms value of initial load (9 p.m.–9 a.m.) = 35.6 per cent of maximum demand
3. Initial load, in per cent of rms peak (35.6/93 × 100) = 38.3 per cent
4. Transformer-rating factor for two hours peak duration and 38.3 per cent initial load = 0.77
5. Transformer rating = 0.77 × 93 = 71.5 per cent of maximum demand

Considering peak 2 as the more severe:

1. Rms value of peak 2 (6–9:30 p.m.) = 78.5 per cent of maximum demand
2. Rms value of initial load (6 a.m.–6 p.m.) = 57.6 per cent of maximum demand
3. Initial load, in per cent of rms peak (57.6/78.5 × 100) = 73.5 per cent
4. Transformer-rating factor for 3.5 hours peak duration and 73.5 per cent initial load = 0.91
5. Transformer rating = 0.91 × 78.5 = 71.3 per cent of maximum demand

For the case cited, then, the same transformer rating is obtained regardless of which peak is assumed to be the more severe. However, if peak 2 had been slightly higher it would have determined the transformer size.

When there is some doubt as to which peak is the most severe, a simple check can be made on peak 2 after the transformer size has been obtained based on peak 1. Determine the rms value of peak 2 such that the maximum half-hour demand of that peak does not exceed its rms value by more than 10 per cent. Then if the rms value of peak 2 is not more than 10 per cent above the transformer size obtained from peak 1, no further calculation is necessary. Otherwise, peak 2 is likely to be the determining factor in the transformer size.

In the case cited in figure 5, the rms value of peak 2 is 78.5 per cent. Since the ratio of the rms value of peak 2 to the transformer rating is only (78.5/71.5 = 1.10), the size determined by peak 1 is satisfactory without further calculation.

A Simplified Method. In the interests of further simplification and reduction in calculation time the rms value of the initial load of many load cycles may be determined partly by inspection and partly by calculation. For example, figure 6 represents a typical cycle which may be treated in this manner.

It may be observed that the fluctuating loads during the 12-hour period previous to the peak have definite trends. For the period from 6 to 9 a.m. (indicated by t_1) the trend of the fluctuations is constant, that is, the equivalent value of the fluctuations over this period may be quite closely approximated by a horizontal line drawn by inspection through the average of the fluctuations (L_1 for t_1 hours).

For the period from 9 a.m. to 6 p.m. (indicated by t_2), the general trend of the fluctuations is upward and may be represented by a straight line drawn by inspection through these fluctuations, increasing from L_1 to L_2 in t_2 hours.

The equivalent or rms value, then, of the initial load for the period t_1+t_2 is

$$L=\sqrt{\frac{L_1^2t_1+{}^1/_3(L_1^2+L_1L_2+L_2^2)t_2}{t_1+t_2}} \qquad (2)$$

AMBIENT TEMPERATURE CORRECTION

So far, this discussion has assumed a daily average ambient air temperature of 30 degrees centigrade. If the average ambient temperature is lower than this, it is only reasonable to expect that the load may be increased somewhat proportionally. In recognition of this fact, the ASA permits an increase in peak load of one per cent of the continuous self-cooled rating for each degree centigrade that the daily average ambient air temperature is below 30 degrees centigrade, except that no further increases are to be made for temperatures below 0 degree centigrade. This means that if a 100-kva transformer is permitted to carry 120 kva for three hours, following continuous 60-kva initial load, in a 30 degrees centigrade ambient, it may be per-

mitted to carry 120+(10 per cent of 100 kva) = 130 kva for three hours in a 20 degrees centigrade ambient; or expressing this another way, a smaller transformer can be used to serve the cycle in a 20 degrees centigrade ambient. The size required will be in the ratio of (120/130 = 0.925) times the rating required for a 30 degrees centigrade ambient.

It is also reasonable to expect that if the daily average ambient temperature is above 30 degrees centigrade, the load should be decreased. The ASA recommends that the peak load be decreased two per cent of the continuous self-cooled rating for each degree centigrade above 30 degrees. (Transformers operating in ambient temperatures higher than 50 degrees centigrade should receive special consideration.) In the case cited above, the 100-kva transformer, operating in a 40 degrees centigrade average air temperature should be loaded at 120 − (20 per cent of 100 kva) = 100 kva for three hours; or, a transformer having a rating of (120/100 = 1.2) times the rating for a 30 degree ambient would be required to serve this load cycle in a 40 degree ambient.

Therefore, in order to determine the transformer rating required to serve a definite load cycle in any other than a 30 degrees centigrade average ambient, the procedure outlined for the equivalent rectangular load method is modified only to the extent of applying a correction factor T to the transformer rating for 30 degrees centigrade.

Thus, the transformer rating for any ambient temperature t in degrees centigrade is

$T \times$ (transformer rating at 30 degrees centigrade)

where $$T = \frac{1}{1 + \frac{(30-t)}{100}(TRF)}$$

for ambient below 30 degrees centigrade

TRF = transformer-rating factor (from figure 3)

(If ambient temperature is less than 0 degrees centigrade, use $t = 0$) or

$$T = \frac{1}{1 - \frac{2(t-30)}{100}(TRF)}$$

for ambient above 30 degrees centigrade (but not over 50 degrees centigrade).

Curves for ambient temperature correction factor T, for temperatures from 0 to 50 degrees centigrade have been prepared in figure 7, which may be found convenient in making ambient temperature corrections to the transformer rating.

SUMMARY

The equivalent rectangular load method of transformer size determination is contingent upon conversion of the fluctuating loads of the actual daily load cycle into a simple thermally equivalent rectangular load cycle, such as is represented by cycles A and B of figure 2.

In order to permit direct comparison of similarly shaped load cycles, which will often eliminate much calculation, it is recommended that the load steps be replotted from the actual load record as a percentage of the integrated one-half hour maximum demand.

The steps in arriving at the proper size of transformer to serve a given daily load cycle may be summarized as follows:

1. *Equivalent* (*RMS*) *Peak Load.* Estimate the approximate duration of the major portion of the load cycle peak and obtain the rms peak load for that duration by equation 1.

As a safeguard against possible overheating of the windings caused by severe short-time demands which may greatly exceed the rms peak, it is recommended that the choice of duration be such that the rms peak load value will not be less than 90 per cent of the integrated one-half hour maximum demand for that peak. If a value less than 90 per cent is obtained, the obvious (and conservative) course is to assume 90 per cent for the rms peak. As an alternative, the estimated duration of the peak may be reduced and a new rms peak value calculated.

It occasionally happens that some parts of the load cycle immediately succeeding but not included in the rms peak exceed the transformer rating obtained in item 5 below. When the rms value of these loads does not exceed the transformer rating by more than 10 per cent, they may be ignored.

2. *Equivalent* (*RMS*) *Initial Continuous Load.* The equivalent initial continuous load is the rms value of the loads for the 12-hour period immediately preceding the rms peak load.

3. *Initial Load in Terms of Peak Load.* Express the rms initial load as a percentage of the rms peak load, item 2/item 1 × 100.

4. *Transformer-Rating Factor.* Obtain the transformer-rating factor from figure 3, corresponding to the rms peak duration (item 1) and the per cent initial load (item 3).

5. *Transformer Size* (*30 Degrees Centigrade Ambient*). Multiply transformer-rating factor by the rms peak to obtain the proper size of distribution transformer to serve the given daily load cycle in an average ambient temperature of 30 degrees centigrade, item 4 × item 1.

6. *Ambient Temperature Correction.* If the average daily ambient air temperature is other than 30 degrees centigrade, the transformer size obtained in item 5 may be multiplied by the ambient temperature correction factor T from figure 7, to obtain the proper transformer size.

REFERENCES

1. Proposed Transformer Standards, **J. E. Clem.** Electrical Engineering (AIEE Transactions), volume 56, January 1937, pages 33–6.

2. Distribution-Transformer Loading, **H. P. Seelye.** Edison Electric Institute Publication number F7, August 1938, pages 1–5.

3. Thermal Performance of Distribution Transformers, **Merrill DeMerit.** Edison Electric Institute Publication number F7, August 1938, pages 7–17.

4. Choosing Transformer Sizes for Distribution Circuits, **R. Rader.** *Electrical World*, volume 107, January 16, 1937, pages 44–5.

5. Transformer Determination From Circuit-Load Data, **R. Rader.** *Electrical World*, volume 110, July 2, 1938, page 48.

6. Transformer Loading on a Temperature Basis, **D. L. Levine.** *Electric Light and Power*, volume 17, March 1939, pages 52–5.

7. Loading Transformers by Temperature, **V. M. Montsinger.** AIEE Transactions, volume 49, 1930, pages 776–92.

8. Predetermination of Self-Cooled Oil-Immersed Transformer Temperature Before Conditions Are Constant, **W. H. Cooney.** AIEE Transactions, volume 44, 1925, pages 611–18.

9. System Survey Leads to Improved Operation, **J. M. Flanigen.** *Electrical World*, volume 96, July 12, 1930, pages 62–5.

10. Hot Spots and Overload Indicators, **Harold Cole.** *Electrical World*, volume 84, August 16, 1924, pages 314–17.

11. Overloading of Power Transformers, **V. M. Montsinger and W. M. Dann.** Electrical Engineering (AIEE Transactions), volume 53, October 1934, pages 1353–5.

12. Distribution Transformer Load Characteristics. Report of the overhead distribution group of the transmission and distribution committee. Edison Electric Institute Publication number F3, April 1938.

13. Operation of Oil-Insulated Transformers on a Temperature Basis, **E. A. Church.** Edison Electric Institute *Bulletin*, volume 4, December 1936, pages 501–09.

14. Effect of Overloads on Transformer Life, **L. C. Nichols.** Electrical Engineering (AIEE Transactions), volume 53, December 1934, pages 1616–21.

15. Heat Dissipation From a 500-Kva Manhole, **L. A. Nettleton.** National Electric Light Association Report, April 1931.

16. Operating Transformers by Temperature, **W. M. Dann.** AIEE Transactions, volume 49, 1930, pages 793–7.

17. Maximum Allowable Loading on Distribution Transformers, **H. P. Seelye and N. A. Pope.** Edison Electric Institute *Bulletin*, volume 7, October, 1939, pages 491–6.

Contents of 1940 Transactions Supplement

SUPPLEMENTING the technical papers and discussions that by the close of the year will have been preprinted from the 1940 volume of AIEE TRANSACTIONS in the 12 monthly Transactions sections of ELECTRICAL ENGINEERING, a "Transactions Supplement" to ELECTRICAL ENGINEERING will be issued in December, in which will be preprinted the 57 additional papers and the many discussions comprising the remainder of the annual TRANSACTIONS volume. This supplement, together with the monthly Transactions sections, therefore will provide in complete form *all* technical papers and discussions published by the Institute during the year. This will be the third in the series of such supplements to be preprinted from the annual TRANSACTIONS volumes under the provisions of the publication policy adopted in 1937 and placed in operation with the 1938 calendar year.

Normally, the 1940 supplement would have contained some 350 pages, comprising some 40 papers and related discussions. However, the improvements in publication procedure adopted at the 1940 AIEE summer convention (*Aug. '40 EE, p. 331–2*) already are being placed in operation, and one effect will be to increase the number of pages included in the 1940 supplement to a total of approximately 600.

Discussions of technical papers, under the revised publication procedures, no longer will be included in the Transactions sections preprinted monthly in ELECTRICAL ENGINEERING, but, of course, will be published complete in the annual TRANSACTIONS volumes. This change was placed in operation with the August issue. Therefore, the 1940 supplement will contain, in addition to the previously mentioned 57 papers and associated discussions, the discussions of papers published in the monthly sections from August to December 1940, inclusive.

Advance orders are required because the number of copies to be printed will be determined by the demand. Therefore, members should be on the alert for the order form which they will receive soon through the mail. The "supplement" will be paper bound and the price will be $1.00 per copy.

To acquaint members with the content of this year's supplement, brief abstracts of the 57 papers to be included are given on this and the following pages, these abstracts taken directly from statements appearing in the respective papers.

Automatic Stations

40-26—Synchronizing Transients and Synchronizers for Large Machines; *R. D. Evans (M'26), F. H. Gulliksen, and C. B. Myhre.* This paper reports an investigation of the transients accompanying synchronizing operations performed under practical conditions, which include some departures from the ideal conditions as to voltage, phase position, and frequency of the "incoming" machine. A typical long-distance transmission system is selected for the study of the transients arising from the synchronizing of one of several similar units connected to the same sending-end bus. This problem reduces to that of a three-machine stability problem which is carried out with the aid of the a-c network calculator. The paper shows the variations in initial and maximum "swing" currents, in voltage, in frequency, and in angular relations that may be produced by synchronizing under unfavorable conditions. The results of this study are then examined from the standpoint of automatic synchronizers and criteria for defining their performances are developed. The latter part of the paper includes a description of a new electronic type of automatic synchronizer, which has been installed on the more recent units at Boulder Dam. The operating features of this synchronizer are discussed.

Basic Sciences

40-5—Analysis of Transient Voltages in Networks; *P. L. Bellaschi (M'34) and A. J. Palermo (A'38).* The analysis and the methods outlined in this paper have been applied to determine transients in windings, to the development of impulse testing and of suitable measurement, and to other problems. These methods and the same simplified approach should be helpful in corresponding applications whether they arise from electrical, acoustical, or heat-flow problems. An important step in the application work is the calculation of circuit elements from the dimensions of the apparatus or the parts that physically make up the network. Another important step is the building up of the equivalent network. Application problems usually require simplification to adapt the problem in a form conducive to calculation. In both these steps sound judgment, based on experience and on a fundamental grasp of network characteristics, is essential in arriving at practical results. To confirm the degree of approach in the calculated results recourse is had naturally to check tests. In this connection, the cathode-ray oscillograph has served as an indispensable tool.

Communication

40-43—The Development of the Civil Aeronautics Authority Instrument Landing System at Indianapolis; *W. E. Jackson, A. Alford (A'39), P. F. Byrne, and H. B. Fischer.* The most important problem in flying today is that of landing a plane under adverse weather conditions. A modern transport plane can take off and fly to the vicinity of its destination through nearly any type of weather by means of modern methods of air navigation. However, it is extremely hazardous to land aircraft with standard equipment under conditions of low ceiling and poor visibility. This limitation is the reason for the majority of flight cancellations of scheduled air transport. The Civil Aeronautics Authority, realizing this to be the bottleneck of safe flying under conditions of low ceiling and poor visibility, has endeavored to overcome this difficulty by fostering the development of a suitable instrument landing system, described in this paper. The system developed utilizes high-frequency radio waves to give to the pilots lateral guidance, vertical guidance, and position fixes.

40-44—The CAA-MIT Microwave Instrument Landing System; *E. L. Bowles (F'33), W. L. Barrow (M'33), W. M. Hall (A'39), F. D. Lewis, and D. E. Kerr.* The problem of developing an instrument landing system in which the pilot is kept informed as to both his location and orientation by the indications of a single instrument was put to the Massachusetts Institute of Technology several years ago by the Civil Aeronautics Authority. The solution of this problem includes the application of centimeter waves, the development of a straight-line glide path, and the realization of a novel instrument combination. Intrinsically and because of recent trends in aircraft navigation these features are believed to represent significant advances in the art. The experimental development described in this paper in general outline was carried on under the sponsorship of the Authority and was built on MIT's background of research on the broad problem of navigation in fog and on work in the short-wave field as a foundation. The apparatus was designed to demonstrate feasibility only. Commercial embodiment of the results is now believed to be within reach of the industry.

40-45—Ultrahigh-Frequency Loop Antennas; *Andrew Alford (A'39) and A. G. Kandoian.* Antennas discussed in this paper were developed for two applications: (1) to serve as elements in radiating systems of localizers and radio ranges used to guide aircraft; and (2) to act as receiving antennas carried by aircraft. These antennas are in some respects similar to low-frequency loop antennas and for this reason will be referred to as ultrahigh-frequency loops. The unique property that makes them useful in the foregoing applications is that they radiate only horizontally polarized waves. The directional characteristics of these antennas are similar to those of a vertical dipole except that the waves emitted are horizontally instead of vertically polarized. Loop antennas can be built for frequencies of the order of ten megacycles. At these frequencies the loop antennas make excellent "omnidirectional" horizontally polarized standard antennas for measuring gain of horizontally polarized directional arrays.

40-52—Calculation and Design of Resistance-Coupled Amplifiers Using Pentode Tubes; *F. E. Terman (M'34), W. R. Hewlett (A'40), C. W. Palmer, and Wen-Yuan Pan.* Resistance-coupled amplifiers employing pentode tubes are used more widely than any other type of voltage amplifier for audio frequencies. In spite of this, no method of analysis is available for correctly calculating the complete characteristics of

such amplifiers, and ordinary design methods involve considerable cut-and-try procedure. This paper presents an analysis taking into account all of the factors of significance in determining the amplification and phase-shift characteristics of ordinary audio-frequency amplifiers employing pentode tubes, together with charts which make it a simple matter to use the analysis; and a systematic procedure for proportioning the coupling network in the plate circuit when the main objective is: (*a*) maximum possible voltage gain, and (*b*) large output voltage.

40-51—High-Speed Voice-Frequency Carrier Telegraph System; *F. B. Bramhall* (*M'39*). A new wide-band carrier telegraph system provides 22 carrier channels, each 300 cycles wide to accommodate four multiplex printers, in the frequency range from 450 to 6,750 cycles; normal speed of operation for each printer is 66 words per minute. However, in no case have more than ten channels been required on any circuit, although the upper channels have been tested. Carrier frequencies are derived from an inductor alternator. All carrier wires are composited, and normal grounded-duplex operation is maintained with little loss. The use of carrier transmission has been a large factor in reducing new wire construction, and further economy is realized by reduction in attendance costs for repeaters and in office space.

40-20—Compressed Powdered Molybdenum Permalloy for High-Quality Inductance Coils; *V. E. Legg* (*M'37*) *and F. J. Given* (*A'28*). The introduction of loading coils in the telephone system at about the turn of the century brought special demands on magnetic and electrical properties of core materials, and set in motion investigations which have had wide influence on the theoretical and practical aspects of ferromagnetism. Continued research for a powdered material having still better intrinsic properties has recently made available new compressed-powder cores which permit further important gains in coils for voice-frequency circuits and in coils for high-frequency carrier-system applications. Molybdenum Permalloy is now produced in the form of compressed powdered cores for inductance coils. Its high permeability and low losses make possible improved quality, or decreased size, without sacrificing coil performance. Its low hysteresis loss reduces modulation enough to permit application where large air-core coils would otherwise be required.

Electrical Machinery

40-102—Performance of Traveling Waves in Coils and Windings; *Reinhold Rudenberg* (*M'38*). The reaction of coils and windings to traveling waves that impinge upon their terminals is an ever-important problem in electric-power systems, from both the practical and the scientific point of view. Transformers as well as alternators are used at increasingly higher voltages and their insulation is thus subjected to switching and lightning surges of ever-increasing severity. On the basis of a new investigation of the electromagnetic coupling of turns and coils, a differential equation of far-reaching validity is derived in which the inductive and capacitive effects of windings for rapid transients are related to the steady-state values. The spatial behavior of standing and traveling waves is considered, leading to the existence of a critical frequency beyond which no harmonic oscillation can penetrate deeper into the winding. This causes a decrease with frequency of the traveling speed of waves which is verified by experiments on transformers. By action of the critical frequency, an incident steep impact penetrates into the winding with a flattened front while the rest of the wave is reflected, causing a steeper terminal distribution of voltage. The reflection, at the neutral point of windings, of the traveling wave with its oscillating forerunners is derived and is found to be in accordance with many experimental results. Propagation through long uniform coils causes a continuous further flattening of the wave front.

40-99—Effective Resistance to Alternating Currents of Multilayer Windings; *Edward Bennett* (*F'18*) *and Sidney C. Larson* (*A'39*). In any multilayer winding carrying an alternating current, each layer of copper lies in the alternating magnetic field set up by the current in all the other layers. Eddy currents are set up in each layer in a direction partly to neutralize the magnetic intensities in the interior of the copper wire in each layer. As a result of the eddy-current losses in the copper, the effective resistance of the winding to the alternating current it carries may be many times its resistance to continuous currents. In a general consideration of these eddy-current losses, it is enlightening to think of the losses in any layer as the result of the superposition of two distributions of current densities. The first distribution of current densities in any layer, n, is that attributed to the magnetic flux set up within the copper of layer n by the current in layer n itself. The second superposed distribution in layer n is that distribution of eddy currents attributed to the magnetic flux set up within the copper of layer n by the alternating current in all the other layers of the winding. It may be called the multilayer-effect distribution. In windings having many layers, the loss caused by this second distribution is many times greater than that caused by the first. The contribution of this paper is the derivation and interpretation of expressions for the current densities and the losses in multilayer windings in which this second effect occurs.

40-98—An Extension of the Method of Symmetrical Components Using Ladder Networks; *Waldo V. Lyon* (*F'33*). The object of this paper is to show how the method of symmetrical components can be extended and applied to synchronous and induction machines when both the stator and rotor windings are connected to unbalanced circuits. Under these conditions there are unbalanced currents in both stator and rotor, consisting of infinite series of harmonic components. These harmonic components differ in frequency by a multiple of the frequency corresponding to the speed of the rotor. The proposed method of analysis can be applied only when the machine and its connected load can be represented by an equivalent circuit. This restriction, however, is not at all serious, since an equivalent circuit can always be found for a three-phase machine if the unbalanced static circuits connected to it are symmetrical about *one* phase. Most of the common unsymmetrical conditions are of this type. Although any problem that can be solved with the aid of equivalent circuits can also be solved without using equivalent circuits, nevertheless the pictorial quality possessed by equivalent circuits has proved of considerable assistance in computing the performance of transformers and of synchronous and induction machines.

40-95—Some Problems in the Standardization of Temperature Ratings of Fractional-Horsepower Motors; *C. G. Veinott* (*M'34*). In this paper statistical data are given on comparisons between different methods of temperature measurement in fractional-horsepower motors. For such motors it is shown that surface thermocouple readings tend to give as much, or slightly more temperature rise than resistance measurements. For this and other reasons, it is proposed, for fractional-horsepower motors, that the surface-thermocouple method be recognized as a distinct method of temperature measurement, instead of classifying it with the thermometer method, as the present standards do; it is suggested that the rating limits for the surface thermocouple be the same as those for the resistance method. It is pointed out that the surface-thermocouple method is often the most convenient one to use in fractional-horsepower-motor application tests, and that it is used by the Underwriters' Laboratories, particularly in their standards on inherent overheating protective devices, the function of which is briefly discussed. Also, the effect of voltage variation upon fractional-horsepower single-phase induction motors is discussed.

40-93—A Study of Short-Time Ratings and Their Application to Intermittent Duty Cycles; *R. E. Hellmund* (*F'13*) *and P. H. McAuley* (*A'36*). Various American standards for electrical apparatus provide, in addition to continuous ratings, certain short-time ratings, based on 5, 15, 30, and 60-minute runs with the apparatus starting cold. Usually these short-time runs do not correspond to conditions met in service This paper discusses a method for applying short-time ratings to intermittent service. It also very briefly touches upon another application problem, namely, the co-ordination of the control and similar auxiliary apparatus and the wiring for short-time-rated apparatus used for intermittent loads. The considerations outlined seem to indicate that the standardization of a limited number of intermittent ratings for applications with the motor at rest during the "off" period would be of little assistance. On the other hand, it seems that reasonably simple guiding rules for the application of the present short-time ratings to many such installations can be devised.

40-3—Starting Performance of Salient-Pole Synchronous Motors; *M. M. Liwschitz* (*M'39*). The author presents in this paper a method of calculating the starting performance of a salient-pole synchronous motor that takes into consideration all the

unsymmetrics of the machine. This method has been used for many years in the calculation and design of machines of various ratings and speeds, and has always given satisfactory results. The assumption is made that magnetic saturation can be neglected. It is then possible to superimpose the five fluxes set up by the five winding systems of the three-phase machine. In doing this, only the fundamentals of these five fluxes are taken into consideration. The five fluxes are replaced by two other fluxes which are stationary with respect to the field structure and whose axes coincide, respectively, with the center lines of the poles and of the interpolar gaps. Furthermore, the unsymmetrical damper winding is replaced by two single-axis windings whose axes also coincide, respectively, with the center-lines of the interpolar gaps.

40-79—Heating of a D-C Armature; *Carl J. Fechheimer (F'14).* It is recognized that temperature measurements of the bare copper, or of the iron in a rotating armature by detectors are generally unsatisfactory because when slip rings are used, too many rings are required if a large number of readings is desired, and if thermocouples are employed, there are liable to be inaccuracies. The method adopted was to use thermocouples, and to take a series of readings which, when plotted against time and extrapolated back to zero time, gave the maximum temperatures. The tests were made on a 300-kw 1,200-rpm 250-volt armature, the d-c machine being direct-connected to a synchronous motor. When the motor generator set was disconnected from the line, dynamic braking was used on the synchronous machine, so that the set was brought to a standstill in very short time, and readings were taken before there was sufficient internal heat flow to modify the maximum temperatures greatly. The maximum temperatures were obtained by plotting temperature-time curves on semi-log paper projected back to the instant of shut-down. It is believed that some of the methods of measurement used were novel, and that descriptions of similar methods have not appeared in the technical press.

40-76—Application of and Operating Experience With Hydrogen-Cooled Synchronous Condensers and Alternators; *Philip Sporn (F'30) and F. M. Porter (A'36).* Until about ten years ago the only cooling medium utilized for electrical rotating machinery was air. The desirability of using hydrogen for this purpose was first suggested about 18 years ago, and as a result a large amount of study and numerous tests were made to determine the advantages of employing this particular gas. The superiority of hydrogen was definitely indicated especially for large high-speed alternators. The difficult problem of devising a simple and reliable shaft seal, as well as the ability of designers to utilize air cooling satisfactorily on machines required by the power industry, delayed the use of hydrogen in generators until several years ago. There has been obtained an experience with hydrogen, on the systems with which the authors are associated and under their operating supervision, of combined continuity and on size and rating of equipment far greater than has been obtained anywhere else. It is the purpose of this paper to describe that experience and indicate its bearing on the design, application, and operation of hydrogen-cooled rotating equipment.

40-78—Determination of Short-Circuit Torques in Turbine Generators by Test; *E. C. Whitney (A'36) and H. E. Criner.* The consideration of short-circuit stresses in turbine generator shafts and frames must be preceded by a knowledge of the developed electrical torque. As far as is known, there have been no extensive measurements of short-circuit torques on modern turbine generators. The object in performing the experiments reported in this paper was to obtain data to check previous equations derived from theoretical considerations and, if necessary, make revisions. The tests were made with various types of short circuits including three-phase line-to-line and line-to-neutral at both 75 and 100 per cent voltage. The line-to-neutral short circuits were taken with two different values of reactance in the neutral. The test results show that the alternating components of torque exist in substantially the same magnitude as calculated theoretically. The test results also indicate the existence of loss torques of a magnitude sufficient to require a method of calculation superior to any heretofore available. It is believed that the terms added to previous torque equations represent the retardation torques quite accurately.

40-80—Theory of Hysteresis-Motor Torque; *B. R. Teare, Jr. (M'36).* The hysteresis motor consists of a wound stator similar to that of an induction motor, and a rotor composed of laminations of a magnetically hard steel assembled on a nonmagnetic arbor. Stator currents establish a revolving field in the rotor, where hysteresis causes the flux density to lag behind the magnetic intensity. The space phase angle between the stator magnetomotive force and the resultant flux gives rise to an impelling torque, produced without the aid of rotor currents or salient poles. Self starting, as well as synchronous, the hysteresis motor has been used in phonographs and traffic-signal controls, and, with modifications, in clocks. The object of the study reported in this paper is the development of a quantitative theory of hysteresis-motor torque, especially in relation to magnetic properties and dimensions. The theory is interpreted physically in an idealized case, and applied to a particular motor to verify the result experimentally.

39-169—The Application of Class-*B* Insulation to Auxiliary-Type D-C Motors in Severe-Duty Service; *F. A. Compton, Jr. (A'39).* This paper is intended to show the advantages of class-*B* insulation for certain applications, especially in d-c motors for severe-duty service. To establish a standard, consistent, and reliable basis of rating for all motors it is suggested that the resistance method of determining temperature rises on d-c severe-duty motors, based on higher temperatures to utilize fully the advantages of class-*B* insulation, be adopted as the preferred method, instead of the currently accepted thermometer method, as the basis for rating motors. The present thermometer method no doubt would be continued as an alternative method for a period of time because of the many motors now rated on that basis. Once an accurate method of determining temperature rise has been standardized, it remains but to give the user operating recommendations relative to magnitude and time of overloads to the end that a motor may be properly applied and the user profit by obtaining the full economic life of the winding insulation. The data presented are necessarily of a somewhat theoretical nature due to the lack of exact information in regard to the life of class-*B* insulation at widely different temperatures.

39-160—Dynamic Characteristics of a Single-Phase Induction Motor; *E. B. Kurtz (F'29).* Small-size single-phase induction motors are used today principally on intermittent duty. In many cases this intermittent starting and stopping is automatically controlled. Loads thus are suddenly applied and as suddenly removed. In order, therefore, thoroughly to understand the motor performance, it becomes necessary to observe its operation under impact conditions. Characteristics so obtained become the dynamic characteristics of the motor, as contrasted with its static characteristics. It is the purpose of this paper: first, to outline the method and procedure employed in obtaining such characteristics; second, to present such characteristics for a typical single-phase repulsion-start induction motor; and third, to compare the mechanical output analytically determined with that actually recorded.

39-141—Temperature Survey of the United States; *J. J. Smith (A'19) and H. W. Tenney (M'36).* In establishing the rating of electrical apparatus many factors are involved. The maximum temperature reached by any part of the insulation is one of these factors. However, the relationship of temperature to rating is a complex function and the rating cannot be considered as a function of temperature alone. In order to obtain authoritative information on atmospheric temperature in all parts of the country, at all seasons of the year, and for long periods, the records of the United States Weather Bureau were consulted. Through the courtesy of the Weather Bureau, analyses of automatic thermograph charts for a limited number of stations were made. Studies were made of these data and of data taken from the reports of the Weather Bureau to suggest suitable forms in which they might be useful to engineers.

39-134—Fractional-Slot and Dead-Coil Windings; *Michel G. Malti (M'34) and Fritz Herzog.* In rotating electrical machinery a great increase in the number of possible combinations of slots, poles, and phases and a reduction in magnetic locking may be achieved by the use of fractional-slot windings, in which the number of slots is not an integer multiple of the product of the number of poles and phases, and dead-coil windings, in which some of the slots contain wedges instead of coil sides. To lay out a winding for given numbers of phases and poles for a given number of slots, in those instances where older known methods cannot be applied, a mathematical solution may be approached through the use of a

vector operator, the *n*th root of unity; vector coil voltages of each coil can be expressed by the operator raised to different powers, the power being equal to the number of the slot. By means of tables the process of laying out a winding according to the theory is reduced to simple algebra for easy application by designers.

39-101—The Rectifier Calculus; *W. Melvin Goodhue (A'31).* The more involved rectifier circuit problems, now becoming important because of the increasing magnitude of rectifier loads, can be solved most readily by the rectifying mathematical operator presented in this paper. Even with the more elementary problems, the final numerical computations are more simple in form than is usually obtained when conventional methods are used. since a lesser number of integrals and trigonometric functions is involved. Application is made to various rectifiers supplied with unbalanced power-line electromotive forces; also some elementary applications of the more simple formulas are included. Because of the wide scope of the subject, a single paper can cover thoroughly only a single field of application, presenting the theorems most suited to that field. In this paper, the calculation of the output of unbalanced rectifiers has been chosen as the field of application.

39-95—Recent Developments in Speed Regulation; *C. R. Hanna (M'39), K. A. Oplinger (M'39), and S. J. Mikina.* This paper deals with recently developed electrical speed governors in which a system-stabilizing influence is incorporated by means of a governor response to time rates of change of speed. It is shown that the response to acceleration constitutes a powerful antihunting means which is anticipatory in action and offsets the effect of time delays in the regulated system. New designs utilizing electrical contacts are described, and a mathematical analysis is given for the determination of the conditions for stability of several typical regulated systems comprising assemblies of rotating electrical machinery. The problem of automatically maintaining constancy of speed in rotating machinery is frequently encountered, aside from prime-mover governing, in such applications as d-c drives for a-c generators whose frequency must be kept unvarying to a high degree of accuracy for signaling purposes, or for exacting test-floor operation. To satisfy the need for a means of effecting such speed regulation, an electrical governor has been developed and an analytical study has been made of the requirements for stable control of the governed system.

Electronics

40-18—A New Electronic Multiplier for Power Frequencies; *W. P. Overbeck (A'39).* Many electrical applications require alternating current at higher frequencies than those normally obtained from the power lines. These applications include: induction heating, the operation of high-speed motors, and the operation of fog horns, and underwater signaling devices. This paper describes a new electronic frequency multiplier which has certain advantages. An incidental feature of the circuit is that it may be used to convert multiphase power to single-phase power with balanced loading of the multiphase lines. The experimental work, at its present stage, is sufficient to show the validity of the mathematical analysis represented in the first few sections of the paper. In adapting the circuit to some applications, some simplification should be possible.

40-74—"Excitron" Mercury-Arc Rectifiers; *O. K. Marti (F'39).* In order to improve the efficiency of mercury-arc rectifiers, an attempt was made to effect a low arc drop by sectionalizing the rectifier unit into as many tanks as anodes. Difficulties with intermittent excitation for ignition of the arc led to the adoption of continuous ignition-excitation. The construction of the Excitron rectifier anode and grid assembly is similar to that of a commercial multiple-anode rectifier, but the design of the ignition and excitation system had to be based on considerations somewhat different from those for the multianode unit. The rectifier tanks are evacuated with standard equipment, and are provided with copper cooling coils. At normal load the arc drop in the new rectifier is about 40 per cent less than in a multiple-anode rectifier, which results in an over-all efficency improvement of about 3 or 4 per cent at an output voltage of 250 volts, and about $1^1/_2$ to 2 per cent at 600 volts.

39-116—Ionization Time of Thyratrons; *A. E. Harrison (A'39).* Grid-controlled vapor-filled rectifiers, or thyratrons, have not been considered in the past for use in blocking and sweep circuits for cold-cathode-type oscillographs because of their inherent ionization time, about which little information was available. A research program to determine the minimum ionization times of various tubes therefore was started in 1938. First results showed that minimum ionization times of 0.3 microsecond were obtainable with mercury-vapor thyratrons if the grid was driven sufficiently positive. These results suggested that these tubes might be used successfully in blocking circuits for high-speed oscillographs. The apparatus devised made possible an extended study of the relation between ionization time and grid overvoltage as a function of anode voltage and vapor temperature (for mercury tubes). For most tubes the ionization time is inversely proportional to the grid overvoltage, but no theory has been suggested to explain this observed relation.

Industrial Power Applications

40-10—The Design Characteristics of Amplidyne Generators; *Alec Fisher (A'30).* This paper describes the essential design features of two-stage dynamoelectric amplifiers, known as "amplidyne" generators. The amplidyne generator is fundamentally an armature-excited machine, in that the armature is essentially the source of main excitation; the armature is also the source of main power output. Typical performance curves and oscillograms are shown, indicating the type of performance that has been found satisfactory in service. The transient performance, which is the real test of an amplidyne generator, indicates that the problems met in designs giving high amplification, speed of response, and stability have been solved successfully. In view of these results, it seems probable that this type of machine will have many useful applications in the automatic control of industrial operations.

40-23—Industrial Applications of Amplidyne Generators; *D. R. Shoults (A'35), M. A. Edwards, and F. E. Crever (A'27).* A considerable number of "amplidyne" generators recently has been applied in conjunction with other electrical apparatus to industrial processes. A summary of these applications indicates that the amplidyne generators are of particular value in conjunction with the so-called "closed-cycle" control system, which may be defined as one in which the controlling agency is actuated in part by some function of the final output in such a manner as to minimize any deviation of this output from an ideal value. Amplidyne generators are controlling load division between large parallel-operating d-c motors; controlling reel tension in a wire-drawing machine; and maintaining close speed regulation of tandem cold-strip mills. They are particularly applicable to systems requiring a quickly reversible source of armature power or field excitation. Where thyratron grid-controlled rectifiers have been used to obtain a quick response characteristic of power proportions, the amplidyne generator offers an alternative method of control which some users may prefer because of the physical nature of the equipment.

40-7—Dynamoelectric Amplifier for Power Control; *E. F. W. Alexanderson (F'20), M. A. Edwards, and K. K. Bowman.* The use of amplifiers has become common knowledge in radio, but the term amplification has seldom been applied to processes in power engineering. Strictly speaking, it may be said that a radio amplifier is only a form of control, because a new source of power is always tapped and the function of the amplifier is to control this power so as to reproduce the changes of energy flow at a higher power level. The type of dynamoelectric amplifier described in this paper was developed to meet new control functions in industry where a high rate of amplification must be combined with a quick and accurate response. It is a two-stage amplifier incorporated in one dynamoelectric machine. In its physical structure it resembles the Winter-Eichberg motor, the Rosenberg generator, and the Pestarini "metadyne", characterized by a pair of short-circuited brushes at right angles to the power brushes. In its functions, it is quite different. The first stage of amplification is from the control field to the short-circuited brushes, and the second stage from the short-circuited brushes to the power brushes. The total amplification is equal to the product of the first- and second-stage amplification.

Instruments and Measurements

40-91—The Output and Optimum Design of Permanent Magnets Subjected to Demagnetizing Forces; *A. J. Hornfeck (A'37) and R. F. Edgar (A'29).* The recent development of new permanent-magnet alloys having a high available energy has ex-

tended considerably the field of permanent-magnet applications. Probably because of the rapid advance in the development of these new alloys and their application to new fields, the development of design methods has lagged behind the application. The permanent magnet does not always lend itself readily to exact calculation, and each new design involves new problems in determining leakage constants and stabilization factors. This paper presents the elements of permanent-magnet design based on the major and minor loop data and magnetic-circuit theory. Equations and methods for the design of permanent magnets having constant external reluctance or applied magnetomotive force are given based on certain assumptions regarding the shape of the demagnetization curve. Since many permanent-magnet problems involve conditions of variable external reluctance or magnetomotive force, further equations and data are presented to show the characteristics and method of design of magnets operating under these conditions.

40-90—New Instruments for Recording Lightning Currents; *C. F. Wagner (F'40) and G. D. McCann (A'38).* Evidence suggests the need for additional statistical knowledge of lightning currents, both in the stroke and in stricken equipment, particularly with respect to the wave shape for periods of time in excess of 50 microseconds. This paper describes some instruments recently developed to accomplish this result. The relatively high cost of the cathode-ray oscillograph and its complexity has limited its use for this purpose. To meet the need for a simple and less expensive instrument that can be distributed in greater numbers at different locations, a new device called the "fulchronograph" has recently been developed. The principal disadvantage of the fulchronograph is its inability to measure high rates of rise of the front of waves. The magnetic surge-front recorder has been developed for recording this property of lightning currents. The magnetic surge integrator is a relatively simple and inexpensive device developed for recording the total charge or the integral of the current in a lightning surge.

40-21—Generalized Bridge Network for Dielectric Measurements; *J. C. Balsbaugh (M'35), A. H. Howell (A'35), and J. V. Dotson.* Recent experience with bridges for the determination of power factor and dielectric constant of small oil samples over a range of frequency has indicated the desirability of improving their characteristics. These improvements or developments are concerned principally with changes in circuit arrangements, a generalized representation of the bridge network in terms of controllable impedances, an increased sensitivity inherent in the bridge itself, and an effective means for controlling the influence of inherent impedances extraneous to the bridge measuring arms on the accuracy, precision, and dependency of the bridge measurements and balances. Further study of a generalized bridge network showed that the precision and dependency of balances of a general five-terminal bridge network is a function of three dependent balances and a dependency factor that is a function of the ratios of certain impedances in the bridge network. This paper evaluates these factors and shows that for certain values of bridge constants and frequency, the use of three balances is a practical necessity and in general permits simplified bridge construction and operation.

39-173—New Developments in Current-Transformer Design; *G. Camilli (M'27).* Noteworthy progress has been made in recent years in the design of current transformers for medium and high voltages. In the past, instrument transformers, with few exceptions, have been designed along the lines of small power transformers and frequently have been unnecessarily bulky with other disadvantages that necessarily attend bulk. This paper describes a new series of high-voltage current transformers with relatively novel principles of construction by means of which volume and weights have been reduced by about half and the factor of safety increased, while more than meeting the standards of accuracy specified by the National Electrical Manufacturers Association. The most striking novel feature of construction of these transformers is the adoption of a highly efficient method of cable insulation by so arranging and shaping the design that the major insulation between the two windings is a closed torus with no ends and hence free from creepage problems.

39-157—Measurement of Very Short Time Lags; *J. M. Bryant (M'13) and M. Newman (A'39).* The time lag of electrical breakdown of various air gaps and solid insulations is of particular importance in co-ordination of insulation for transient lightning surges. Generally, time lag of breakdown is in part a function of chance ionization conditions in the breakdown path, and therefore the measurements often become of a statistical nature. Therefore, where a large number of measurements are to be made, a direct method giving immediate readings free from the delays of photographic development would be a valuable auxiliary to cathode-ray oscillography. Direct-reading measurements of time lag in surge circuits have been obtained by an electronic-relay method using two surge waves on a calibrated artificial transmission line. Time definitions were obtainable down to 10^{-9} second. Although a cathode-ray oscillograph was designed to give comparable recording speeds, the electronic-relay method had advantages of simplicity and direct readings, making it a useful auxiliary instrument for rapid work.

39-156—Electronic Measurement of Surge-Crest Voltages; *J. M. Bryant (M'13) and M. Newman (A'39).* An electronic voltmeter has been developed for measuring surge-crest voltages, particularly in connection with laboratory lightning co-ordination tests of insulation breakdown. Simplicity of operation with high accuracy is obtained, as well as practical independence of time lags and of the form and duration of the waves encountered in engineering test work. A multiple bank of the crest-measuring units is applied in an instrument for giving directly the crest value for any particular surge in a single test to within one per cent accuracy. The instrument is applicable for general research on very-short-time-duration surge-voltage phenomena as well as for convenient standardized laboratory testing of insulation.

39-125—Some Practical Measuring Devices; *Lloyd F. Hunt (F'38).* In the operation of a large power system, measurements often are desirable that are not obtainable from the usual manufactured devices. It therefore becomes necessary to make some unusual devices to fulfill the need. For example, a simple recording transmitting device is used to make a record of the travel of oil-switch contacts on oscillograms of operations, and thus provides important information. Microammeters may be used for low-cost indicators of voltage on high-voltage lines. High-speed disturbance recorders give records for study of transmission faults, and enable dispatchers to determine the approximate location of faults. An a-c voltmeter may be used as an indicator to permit a station operator to observe the starting of synchronous condensers.

40-39—The "Speedomax" Power-Level Recorder; *William Russell Clark (A'37).* Power-level and attenuation measurements are increasing in importance, particularly in the radio and telephone industries where it is essential to know the power-level variations in electrical circuits and acoustic devices, the gain of amplifiers, and the attenuation of filters or communication lines at various frequencies. Manual methods of obtaining these measurements have been fairly well standardized, but are not applicable for many production tests. An automatic recorder should record faithfully rapid or slow variations in power level with time, be independent of frequency variations within the range of interest, and draw a smooth curve in order to eliminate the need for interpolation. As a result of the need for such a recorder, the "Speedomax" power-level recorder was developed to operate directly from a 115-volt 60-cycle supply. The scale of the instrument described is linear in decibels, with a range of 40 decibels above a zero level of 0.01 milliwatt and an input impedance of 135 ohms. It is designed to operate between 150 and 150,000 cycles and be accurate to one-half per cent of full scale over this range. The speed of response is such that the pen will traverse any part of the ten-inch chart and arrive at complete balance without overshooting in approximately one second.

39-92—A New Measuring Instrument for Direct Current; *H. T. Faus (M'34) and A. J. Corson (A'24).* Recent advances in the development of alloys for permanent magnets have been of particular interest to the instrument designer, who utilizes these materials both in d-c instruments and in the damping systems of a-c instruments. The distinguishing characteristics of the new aluminum-nickel-cobalt alloys (Alnico) are high values of coercive force and available energy. In instrument application, these qualities result in a magnet of short length and relatively high gap flux density. This paper describes the design of a new d-c measuring instrument of the permanent-magnet moving-coil type. Alnico is utilized as the magnet alloy, and the factors involved in the application of this material to instrument design are discussed. A moving system for use with the Alnico magnet system

is described and the resulting instrument performance summarized.

Power Generation

39-119—Mingled Hydro and Steam Power Production in California—Past, Present, and Future; *A. H. Markwart.* Production of electric power in California has passed through two phases of development and now is in the third. The first was a pioneer phase with the establishment of many plants; the second was that of interconnection and co-ordination; and the third is that of large-scale power production in Federal multipurpose projects. Economic considerations dictated the balance between steam and hydro plants until the development of the present phase, when the introduction of large amounts of power in some regions is creating major problems with respect to absorption. Future growth appears to lie in steam plants in southern California, where relatively little potential water power remains undeveloped, and in hydro plants in the northern part of the state, where there are projects that can be developed and combined with steam-electric plants to produce mingled power agreeable to the load on a competitive basis.

Power Transmission and Distribution

40-121—The Type-CB Impregnated-Paper Cable; *Samuel J. Rosch (A'15).* Since the importance of low dielectric loss in impregnated-paper cable was first recognized, attention has been constantly directed to securing lower power factor during the life of the cable. It is the object of this paper to present a progress report on a new method for attacking the problem of insulation instability by the use of carbon-black-protected cable. Although initially of high quality, the oil when placed under heat and electrical stress becomes subject to deterioration because nearly all antioxidants are solid bodies which may be partially but not completely soluble in oil. When the insulation consists of paper impregnated with oil containing an antioxidant, the paper may act as a partial filter for these solid bodies. To secure definite chemical and electrical stabilization, the means employed should be effective during the life of the cable and remain in its original position. One means for accomplishing this is to incorporate highly absorbent carbon black into paper during the pulp stage and to place this carbon-black paper in the cable structure. Standard methods of cable processing are then followed. Inherently, the carbon-black-paper tapes shield from the electric field all materials which they may adsorb. In addition, they tend to smooth out the configuration of stranded conductors and thereby reduce the maximum stress.

40-17—Engineering Features of the 230-Kv Boulder-Chino Transmission Line of the Southern California Edison Company, Ltd.; *Alex A. Kroneberg (M'34) and E. M. Hunter (M'36).* This paper deals with the problem of transmitting Boulder Dam power to the Southern California Edison Company's system. The economic restrictions of base-load operation plus the necessity for a high degree of reliable service, owing to the relatively large amount of power to be transmitted, has led to the design of a single-circuit transmission line with two overhead ground wires, counterpoises, and ground-fault neutralizers with an expected service-continuity record closely approaching that heretofore obtainable only by two transmission lines on separate rights-of-way with crossovers and paralleling switching stations. With this new design, flashovers caused by lightning are expected to be reduced to single line-to-ground faults by the two overhead ground wires and counterpoises and suppressed by the ground-fault neutralizers. Permanent ground faults are not to be removed immediately, but are to be allowed to remain on the line until the load can be backed off the Boulder Dam generators. This alleviates the shock to the system which might otherwise occur if the load was rejected immediately. Operating in this manner is possible with ground-fault neutralizers in the power transformer neutrals. (The design features of this line also were discussed in an article published in the November 1939 issue of Electrical Engineering, pages 463–5.)

40-9—Surge Characteristics of a Buried Bare Wire; *E. D. Sunde (A'36).* Buried bare wires are frequently used as grounds or counterpoises for transmission-line towers and also as shield wires for underground rubber-covered telephone wires. Experience has verified the effectiveness of such wires in reducing insulator flashovers for direct strokes to transmission towers and breakdowns of underground rubber-covered wires due to surges. Quantitative relations between surge characteristics of the wires and various fundamental constants, however, are incomplete. In the theoretical investigation presented in this paper, a previous study of the propagation of alternating currents along conductors with large leakage to ground is extended to include the propagation of transient impulses, and the results are applied to the calculation of certain cases of practical interest. The paper is divided into four parts, the first dealing with propagation of alternating and square-front (unit step) current waves in wires of infinite length, the second with surge impedances under the same conditions. The third part considers current propagation and surge impedances for unit step current and wires of finite length, and the fourth part, impedances for surge currents of shape similar to that encountered in case of lightning.

39-165—Lightning Investigation on a 220-Kv System—III; *Edgar Bell (M'35).* Lightning research has been conducted for the past 13 years by the Pennsylvania Power and Light Company, the General Electric Company, and the Ebasco Services, Inc., chiefly upon that portion of the Pennsylvania-New Jersey 220-kv interconnection circuit between Wallenpaupack and Siegfried, Pa. This 65-mile circuit is of steel-reinforced aluminum cable, 3-conductor horizontal-configuration steel-tower construction, having originally 14-unit insulation. Since 1932 the 28-mile section from Wallenpaupack to Bushkill has been called the Wallenpaupack tap, and the remainder constitutes part of the Siegfried-Roseland line. The original line was without overhead ground wires. This paper briefly describes surge-crest-ammeter measurements of lightning strokes and structure-network currents, and summarizes transmission-line experience with and without overhead ground wires, buried-cable grounding networks, expulsion protective gaps, station-type lightning arresters, and spillway gaps.

39-158—Analysis of Factors Which Influence the Application, Operation, and Design of Shunt-Capacitor Equipments Switched in Large Banks; *J. W. Butler (M'38).* The increase in knowledge of the benefits afforded by capacitors through experience and analysis, coupled with the price reductions effected through advances in design and manufacture, has logically stimulated their use in fields where switching during the day, as governed by load and voltage conditions, is advantageous, desirable, and economically sound. These types of applications impose different duties upon the capacitors as well as upon the disconnecting equipments and associated devices, and the question naturally arises as to their effect upon the design and operation of the equipment. This paper offers a discussion and an analysis of the more pertinent of these problems. The conclusions drawn pertain in general to installations of 6,900 volts and below. The higher-voltage equipments may require additional considerations. The interesting and encouraging conclusion is that in general the cases analyzed show that the duties imposed are well within the limitations of the standard product.

39-113—Tests on Oil-Impregnated Paper—IV—Mechanism of Breakdown; *Hubert H. Race (F'39).* In three previous papers some of the results of studies on miniature cable specimens started in 1934 have been reported. In the first two papers the relative life histories and the results of post-mortem examinations were given for (*a*) specimens saturated with gas at one atmosphere pressure, (*b*) specimens saturated with gas at 200 pounds per square inch pressure, and (*c*) specimens gas free but under one atmosphere liquid pressure. The third paper presented data on fluid flow through cable paper and showed that even with high-viscosity impregnants and low-permeability papers there was sufficient flow through the specimens to prevent void formation. It is the purpose of this paper to present observations regarding the mechanism of failure of the gas-free specimens.

39-136—Painting the Golden Gate International Exposition With Light; *A. F. Dickerson and H. E. Mahan (A'28).* Since the introduction of the incandescent lamp in 1879 until the Panama-Pacific International Exposition in 1915, the decorative lighting of expositions took the form of outline lighting by strings of incandescent lamps. The incandescent-lamp floodlight assumes the major role in modern lighting because the incandescent lamp lends itself to dimming, color correction, and control of the light distribution. At the Golden Gate International Exposition the incandescent lamp is supplemented by three new light sources which make possible effects hitherto difficult to obtain. These light sources are

the fluorescent tube, the high-intensity mercury lamp, and the red-purple-bulb mercury lamp for obtaining ultraviolet radiation. Each has its distinct field of application. To design lighting systems of this character requires that the engineer approach his problem with tolerance toward the view of others. The lighting must be in harmony with the work of the architects, artists, sculptors, and horticulturists, and strictly engineering considerations subordinated in many instances to those of aesthetics. This spirit of compromise between the science and art of illumination may be noted in the effects described in this paper. (See also *EE, June '39, p. 234–50.*)

Protective Devices

39-127—12-Kv Metal-Enclosed Bus and Switch Structure, Station "C", Oakland, Pacific Gas and Electric Company; *F. S. Benson (M'36) and H. E. Strang (A'28).* The East Bay metropolitan area, comprising cities on the east shore of San Francisco Bay, and with a population exceeding 500,000, is supplied with electric power from 110-kv transmission lines of a hydroelectric system by substations that reduce the voltage to 12 kv and by station *C*, a steam plant. Growth of capacity made switchgear at station *C* inadequate, and decision was made to erect a new switch house. The new two-story building, of reinforced concrete, has neither windows nor skylights, and was completely finished before any electrical installation was begun. No conduits were cast in the station walls or floor. The details of the metal-enclosed switchgear were designed by the manufacturer, the structure being built to the power company's specifications.

Research

39-152—Importance of Gas in Electrodes for the Glow-to-Arc Transition; *F. A. Maxfield (M'39), H. R. Hegbar, and J. R. Eaton (M'35).* This paper deals with studies of an unstable glow discharge in mercury vapor which lend support to the theory that the causes initiating glow-to-arc transitions are probably small bursts of gas nonuniformly emitted from the electrode surface. The experimental studies show that the transition probability continually decreases when the electrode is kept hot and bombarded with positive ions over a period of several days; but when the electrode is allowed to remain cold, even overnight, the transition probability is greatly increased. Two quite different curves of transition probability as a function of oil-bath temperature can be obtained, depending upon the glow current used. The results indicate that the complete elimination of this cause for the glow-to-arc transition is very unlikely, since a complete outgassing of the electrodes is impossible in any vapor tube.

39-111—The Dielectric Strength and Life of Impregnated Paper Insulation—The Influence of the Density of the Paper; *J. B. Whitehead (F'12).* This paper reports the results of a part of an experimental program of study of the life of impregnated paper insulation, particularly as related to those changes occasioned by the presence of electric stress, carried out under the auspices of the Engineering Foundation with the sponsorship of the AIEE. The method used is to make accelerated life and other electrical tests on samples in which the only variable is some one of the physical properties of the paper. In the present tests this variable has been the density of the paper. Few if any definite data have been presented as to the influence of variations in density on the electrical characteristics of impregnated paper and its performance in service. The results of the present study will be found to be quite definite. From what has been said, however, it will be recognized that the influence of variations in density of the paper must be considered as only one element of the general problem of cable design, and that the influence of a variation in density on other important physical properties must be duly considered in particular cases.

39-112—Dielectric Strength of Insulating Liquids in a Continuously Circulating System; *Hubert H. Race (F'39).* One of the most important, and probably the least understood, of the various properties of liquid dielectrics is the mechanism of electrical breakdown. One of the concepts in the past has been that breakdown is initiated by ionization in gas bubbles thrown out of solution of suspension in the liquid. As a new experimental approach to this problem, a closed system was set up in which the liquid could be continuously circulated through the dielectric-strength cell with filters, dryers, and a degasifier in series in the system so that solid particles, moisture, and dissolved gas could be removed. Arrangements were made so that the partial pressure of gas in solution could be varied from less than 0.01 micron to one atmosphere. For a filtered, water-free insulating liquid, the dielectric strength was found to be unaffected by the partial pressure of air in solution in the range studied. Large average deviations were observed which support the opinion that the condition of the electrode surface is a major controlling factor. In one liquid a diffuse glow, termed "electroluminescence", was observed at gradients well below breakdown.

39-108—Corona Discharge on Rubber-Insulated Cables; *E. B. Paine (M'12) and H. A. Brown (M'26).* When rubber-insulated cables operate at higher than 1,500 volts potential, conditions may be favorable to the production of corona discharge over all or a portion of the outer surface of the insulation, or its braid covering. The cable may be on an inner metal conduit surface, or lie on a grounded flat metal surface, both of these conditions being favorable to surface corona at sufficiently high voltages. Corona discharge is known to be objectionable because of the chemical effect of the actinic ozone produced, and because of inductive and radiation effects, notably interference with radio reception. The purpose of this investigation was twofold: First, it was desired to learn how cables of different designs, ratings, insulation characteristics, etc., compared as to corona behavior when an operating condition is imposed which tends to produce corona at nominal voltages; second, it was desired to learn what effect, if any, corona discharge may have on the power factor of the insulation under the test conditions. The conclusions show that corona discharge may well occur at or near normal operating voltages under conditions liable to be obtained in actual use, and in addition to the previously assumed effects of ozone production, power factor may be affected.

39-109—Characteristics of Restricted Ionization and Its Relation to Voids in Insulating Materials; *C. L. Dawes (F'35) and P. H. Humphries (M'34).* The phenomena accompanying the formation of corona about cylindrical conductors and the laws governing such corona formation have been under investigation for a number of years, and the relations of such corona loss to voltage gradient, pressure, temperature, and the geometry of the system are now q ite completely rationalized. Corona or ionization also occurs in restricted spaces, such as the voids which frequently are formed in dielectrics during their fabrication, and this corona formation has important effects on the behavior of such dielectrics. In the investigations described in this paper, a large number of measurements of restricted ionization under various conditions of voltage, pressure, and frequency have been made. From the data so obtained an attempt has been made to establish certain rational laws for restricted ionization. The phenomena accompanying restricted ionization are far more complicated than those accompanying corona about a cylindrical conductor, and the laws therefore cannot always be reduced to simple forms. Also, this investigation contributes to the knowledge of the phenomena which, in general, accompany the ionization spark-over of gases.

Transportation

40-15—Unsolved Problems of Electrical Engineering in the Field of Transportation; *J. A. Noertker (M'32).* Competition is making it increasingly clear that if public transportation is to survive, the industry must strive toward higher levels of convenience, speed, comfort, efficiency, and attractiveness. Today, the public assumes that safety has been given adequate consideration. This, then, is taken as the major premise of the paper: that any development that offers hope for improving these factors, through the effort of electrical engineers, is a proper problem for consideration. The author outlines some of the problems facing electrical engineers of the transportation industry, particularly those in the railroad and urban transportation field. (Essential substance of this paper was included in an article published in the March 1940 issue of ELECTRICAL ENGINEERING, pages 113–17.)

39-139—Electrical Equipment of the Union Pacific Steam-Electric Locomotive; *M. R. Hanna (A'03) and J. F. Tritle (A'06).* The development of the steam-electric locomotive for the Union Pacific Railroad represents the culmination of more than two years of co-operative design and research by scientists, engineers, and officials of the railroad and of the various manufacturers of equipment for this outstanding example of

modern motive power. This paper deals primarily with the electrical details but a comprehensive picture of the general features of this recent development is included. A number of departures were made from conventional designs in order fully to utilize the possibilities of this new type of motive power. New methods of construction were devised permitting material reductions in weight and space requirements.

Welding

40-56—Resistance of the Spot Weld; *Ladislav Ciganek.* With the majority of resistance-welding machines, welding current is determined by the internal impedance of the machine, the resistance of the weld being but a small part of the impedance of the entire circuit. Therefore the resistance of the heated metal being welded is the only variable that can change the output at the electrodes of a given machine for a given internal impedance. Designers of welding machines are familiar with the value for different welding jobs; however, there has been a lack of systematic study of this resistance. This paper indicates one method of evaluating spot-weld resistance. Investigations were restricted to the most important case—the welding of the ordinary mild-steel sheets. Both calculated and measured data are included for comparison.

40-11—Power-Factor Correction of Resistance-Welding Machines by Series Capacitors; *L. G. Levoy, Jr. (A'31).* The problem of power-factor correction of resistance-welding machines is of current interest because of their widespread and rapidly growing application. In addition, new and improved methods of production have diminished the cost of capacitors to a point where it now becomes economically feasible to apply them where previously the cost was prohibitive. This paper explains briefly why the usual method of power-factor correction by means of shunt capacitors is not satisfactory for this service, and presents a system of power-factor correction using series capacitors which avoids the undesirable characteristics of shunt capacitors. The method is applicable both to synchronous and non-synchronous controls. The operating characteristics of the power-factor-corrected welding machine, and several methods of current control which may be used with it, are described. Oscillograms of an actual welding machine taken under various operating conditions show a resistance-welding machine which normally demands 434 kva at 41.5 per cent lagging power factor being served with a line demand of 181 kva at unity power factor.

The forthcoming AIEE winter convention, January 27–31, 1941, will be held in Philadelphia, Pa. Shown here is a view taken looking west from City Hall along the Benjamin Franklin Parkway. The Bellevue-Stratford Hotel will be headquarters for the convention, for which many unusual features are being planned

Institute Activities

Science and Superstition

Address delivered at the 1940 AIEE Pacific Coast Convention, Los Angeles, by President Royal W. Sorensen

THE principle of co-operation—dependence upon the other fellow for what we may do—and its reciprocate—a willingness to help the other fellow—is not only good Americanism, but also therein lies the reason for the success of the American Institute of Electrical Engineers. The Institute was organized in 1884: "For the advancement of the theory and practice of electrical engineering and of the allied arts and sciences and the maintenance of a high professional standing among its members." It has never deviated from those objectives. It promotes its objects through the medium of its conventions, its publications, the work of its staff organizations, and such other services as it may render to the profession, its members, and the public. It is maintained by means of a tax on its members and such other income as it may receive from endowments, investments, advertising, and other sources. Therein lies one of its problems. Everyone dislikes taxation. Sometimes men forget the joy they had when they became members of the Institute and remember only the dues they pay. Clubs, lodges, and even governments also have members who fail to realize that these institutions can survive and serve only in proportion to funds made available by some form of taxation. In organizations such as this, the tax is almost insignificant in proportion to the benefits available for its members. Those who object to the payment of such dues must do so because of a superstition that all taxes are bad, rather than because of any scientific basis for complaint.

Anyone who becomes president of the AIEE must have attended many conventions, such as this, and made contributions to the work of the Institute, not only in the form of technical papers, but also by participating in some of its administrative activities.

The first AIEE convention that I was privileged to attend was the 1911 Pacific Coast convention held in Los Angeles in the old Alexandria Hotel. That convention I shall never forget. I met there many engineers previously known to me only by reputation, and started friendships with men who spoke my own professional language that have continued with increasing value up to the present day. I learned there the value of associating the personality of those who wrote papers with the language in which those papers were couched. The next year, I had the privilege of attending the 1912 annual convention in Boston, where I again met many engineers whose names were known to me only through their published papers. I distinctly recall how these two opportunities to contact the authors of papers made those papers live in a way that never would have been possible without opportunity to meet the authors and note their manner of approach to the problems about which they wrote.

I think everyone who has had like experiences at our conventions feels that if no other return were given for the dues we pay to be members of the Institute, we would be getting a very generous return on our investment.

Years of observation since those two conventions have shown me that engineers who read technical publications are the engineers who grow in the profession. Reading becomes so much more interesting when the reader knows the writer. Indeed for some time the Institute has emphasized increasing the number of conventions and District and Section meetings, thus increasing the number of opportunities for engineers to have fellowship with each other.

Institute convention programs include usually three groups of so-called technical activities: the regular paper-presentation and discussion group, the student technical-paper group, and the technical conferences. Correlated with these are the social phases of the convention and the many committee meetings for which conventions afford opportunity. Each of these phases of our many-sided program well justifies our coming together. Each session, be it a technical session, a technical conference, or just a committee meeting, provides a convenient arrangement for the presentation of the results of much thought and many hours of detailed work on the part of those who contribute. Convention programs move smoothly because men have volunteered time and effort in preparing for them and because the staff of Institute employees has done well the work essential to their proper and efficient conduct. The real work of the Institute, however, is done not at conventions, but between conventions at the desks and in the laboratories of the workers.

At the several conventions held every year, our members present from 25 to 75 technical papers per convention. Every one of these papers is a very condensed summary of some special program involving many hours of work and usually much expense for equipment. Assume, for the purpose of illustration, that each of you in order to obtain the information contained in a paper had to make a choice between doing the work reported and paying a sum equivalent to a year's dues for membership in the Institute. Which would you do?

Are there members of the Institute who are so busy or so proficient that they do not read at least a few papers per year? If we have members so productive, it is my impression that they should take a few hours off from such productivity and write a paper that will tell us what they are doing. The Institute is now publishing, and thus giving its members opportunity to read, about 160 technical papers per year. Some members seem to think this too many, for all too often we hear the excuse: "I think I shall not keep up my Institute membership because it publishes so many papers I cannot read them."

That is not the only superstition our members have, for on the other hand we hear men who have written papers and cannot get them published as quickly as they would like say: "What is the matter with the Institute? Why doesn't it publish more papers so I can have a discussion of my special subject matter?" Also, some of our members who would like to read papers that are not published, say: "Why doesn't the Institute find it possible to publish more papers that will help me in my work?"

The complaint about lack of increased publication facilities is quite valid, but there is a sound answer to the limitation; namely, the Institute balances its budget each year. About $115,000 or 36 per cent of the total yearly Institute disbursements is spent for publications. The rest of our operating expenditure is about as low, considering our membership, as can be, and is quite constant. It is evident, therefore, that if the members wish more papers published, they can provide for increased publication only by increasing our income. One way to do that is to educate executives and outstanding engineers employed by electrical industries, particularly some of the smaller ones, to realize that although they may have received promotions that have caused them to lose close touch with our technical activities, the benefits to their businesses provided by the AIEE should confer upon them a sense of responsibility for continuing membership in the Institute. Another way industries founded upon electrical engineering can help is to use advertising space in ELECTRICAL ENGINEERING. Such space is available at very reasonable cost. Of course, it may be difficult to show industrial companies, particularly operating companies, just how an advertisement in ELECTRICAL ENGINEERING, which is read by engineers, will increase their business. The value of advertising as reflected by direct response is always difficult to determine, but it seems logical to suggest that the free advertising inherent in papers prepared by engineers should be supplemented somewhat by advertising space purchased by the companies employing the engineers who write the papers. If any of you think ELECTRICAL ENGINEERING would not like to have more paid advertising, that is just another superstition.

Although I have already spoken extensively about publications, and although

for the next point I wish to make I could speak of the work of any one of several other committees, I will use the work of the publication committee to illustrate the diligence with which practically all our committees conduct their work. If you cannot take the time to read the whole annual report in the July ELECTRICAL ENGINEERING and have not read some of the committee reports, just read the report of the publication committee and then read in the August issue the item regarding future publication policies. I think that when you have read this material you will begin to appreciate that our committee members do work hard in the conduct of Institute affairs. However, unless you are a member of the board of directors or the president, you will never have a fair opportunity to know how generous our members are in responding to requests for committee work, or how efficient and loyal are Secretary Henline and his staff of Institute employees who keep the home fires burning at 33 West 39th Street. As we are meeting in Los Angeles, I think it only fair to say that the Los Angeles Section should be proud of the fact that Mr. Henninger, one of its former members, is the able editor of ELECTRICAL ENGINEERING, which under his direction has high reputation as an outstanding technical publication.

Our profession is engineering; our job is to engineer. To the public mind this means to make devices that will ease the burdens of men and improve the standards of living for the inhabitants of this old world—such a sorry place in which to live for some of us, and such a glorious place for the rest of us. For most of the members here, the world is a paradise in so far as personal comfort, enjoyment, and freedom to pursue our profession is concerned. When we extend our thinking beyond the horizon of the Western Hemisphere, how different is the picture. All about us the world that we were beginning to think so secure is being consumed by a fire more terrible than the dread forest fires that do so much damage in our mountains. Will our national firebreaks—the oceans, the Monroe Doctrine, and such other defenses as we may set up—prove adequate? Or will the flames raging abroad leap these barriers and embroil us in the conflagrations? Have we been so busy as engineers making gadgets that we have forgotten that the mere making of such things is not enough, and neglected to perform the more important function of telling the world how the devices we make should be used? Are we permitting our profession to be just a tool in the hands of power-mad or just plain ignorant and superstitious persons, who are tearing down faster than we can build? Have we confused making life easy with making life worth living?

Recently a nation chose as its leader a human failure; "a tortured, neurotic, flophouse derelict" who could not even earn daily bread was set at the head of a government. A nation that had produced great men who accomplished great things in art, literature, science, and commerce, and even in the development of a form of government, followed his ravings and promises for a skimpy mess of pottage. When men have returned to the habits of the jungle and fallen even lower (for the jungle beast, because he can think no further, stops killing when his belly is full) is it any wonder they have set the world on fire? When things such as we know are now going on in Europe and Asia are the news of the day, should we not pause and ask ourselves, "Do we always do better in the selection of our leaders?" Does it seem possible that the scientists and engineers of Germany could sanction the use now being made of their mechanical children? If those engineers and scientists had become thoroughly conversant with what was brewing and had become active in the governmental affairs of their country before it was too late, would they have permitted the situation which now confronts the world? I think not.

During the summer of 1936, I was privileged to attend the Third World Power Conference as it met in Washington, D. C. During the sessions there and on the 9,000-mile tour of the United States, which followed those sessions and was made by 242 engineers from many nations, I observed no nationalistic hostility among the engineers making the tour—this notwithstanding the fact that to be allowed to come as delegates to this conference an engineer would certainly have to be in favor with his government—and, mind you, these events occurred only four years ago. Not having had the privilege of travel in foreign countries, on that trip I had my first direct contact with men who had to work under restrictions applied by their country that would indeed be onerous to us, and I think I realized for the first time the potential trends for explosions in Europe. As an illustration of the restrictions, I discovered that the German delegates, after being provided with traveling fare and living expenses while en route, were allowed to take out of Germany only $100 each to spend in the United States for a stay of about one month. One of the engineers so restricted said to me: "I have been invited to the house of an engineer in this country for a week-end stay. I am sure he cannot realize what that means to a man who must live in this country four weeks on $100 allowance and attend a World Power Conference."

The ease with which an international explosion could be started in Europe was conveyed to me through the remarks of a young German, not an engineer but a guide on the trip. A particularly pertinent remark ran about as follows: "You Americans, with your broad areas in which you can operate, do not understand European conditions where little countries are close together. Inherent in those conditions is the fact that one country must be in control. We Germans will never be satisfied until Germany is that country." If the citizens of the countries involved feel that way, and as long as any one of them resorts to armed force as a means of obtaining that control, there can be no lasting peace program. If perchance some one nation after getting this control should continue in power by the force of armed tyranny only, what a sad apparent peace that would be for Europe. And how long would it be before that tyranny sought enlarged scope in the Americas?

February 16th of this year in this same hotel, I spoke before a gathering made up of persons having much the same spirit as the group assembled here this morning. That group was made up of leading citizens of Los Angeles from all walks of life and, since it was an evening meeting, half of them were our ladies of the family who came to help us do honor to the special guests of the evening. The occasion to which I refer was designated as a banquet to honor America's modern pioneers on the frontiers of industry. It was just one of a number of similar banquets held in the larger cities of the United States. The honor guests were inventors, a number of them members of our own Institute. We paid them tribute, because as pioneers in modern activities they had sacrificed time and energy and had achieved success in developing new, useful electrical and mechanical devices. As a background for the tribute to those pioneers, I described the pioneer life of men and women who moved westward and made farms of wild virgin country in days so recent as to come within my observation.

Those "Westward Ho" pioneers of my boyhood days and the modern or technical pioneers we were honoring that February evening were not seeking ease and comfort, but were seeking freedom of opportunity. Not having heard of social security, those pioneers did not expect freedom of opportunity to mean a life easier than the one to which they had been accustomed. In fact, they deliberately gave up such comforts of civilization as were then available for them, and "struck out" for a life of severe hardship and great adventure. The hardships were "taken in their stride" as being all in a day's work, because those pioneers had their eyes fixed on a future that would bring its own reward in the form of accomplishment which, in turn, would open opportunity for more accomplishment. Social security and the more abundant life are not team mates, but enemies; we can have one or the other, but not both. I have been told that in some oriental countries the inhabitants have social security—they all starve together. Statistics show that if we were to divide all the annual incomes of our rich men among the rest of us, each of us would receive about 66 cents more per year.

The engineer is still a pioneer; his acquirement of new fields is not exhausted. Hence, like the well-known pioneers I have mentioned, the engineer to date has not found much necessity for thinking in terms of social security, but is giving his attention to building new things. The pioneer was not interested in social security, because he had confidence in his ability to wrest a living for himself and family from nature. The engineer is adapted by his education to do those things which the world demands and for which it will pay, although the compensation for his services may not be all he desires. But how about the man who today cannot find, even if he "go West," a piece of land upon which he can settle and wrestle with nature, and who also has no training in engineering or in some other profession in which there is a demand for men? We must do all we can for him by teaching him to find what the world wants and how to do it.

The engineer has been conducting programs for the defense of America for many years, but he has called it a program of progress. He set up a front line of defense when he made the cotton gin, and yet another when he produced the reaper and the binder, and yet others when he produced the electric light, the bicycle, the automobile, the radio, and so on down the line. Each activity made for new work and an improved standard of living. Our products of engineering

have been good; our methods of production have been good; but what about the use to which our products are being put?

When a country is in danger, the engineer is in great demand, because his profession enables him to make instruments of war which are essential for defense against other instruments of war.

A recent book entitled, "Engineers and Engineering in the Renaissance", by the late Colonel Parsons, traces engineering back almost to medieval times. The outstanding engineer of the Renaissance period described by Colonel Parsons was Leonardo da Vinci. He was first in demand by his country as a military engineer. In that capacity he devised many forms of weapons and also fortifications for defense against those weapons. During more peaceful times, he devoted his efforts, as did other engineers, to the regular forms of engineering then known, such as water supply, drainage, and structures.

Our country is in danger. We have agreed that we must prepare for defense. In doing so, we must spend for war machinery unbelievable amounts of money, time, and energy that in a world at peace could be used to so much better advantage. I pray God war may never come to us, but it is on the way with the speed of a prairie fire and, just as certainly as the prairie farmer in the path of such a fire and without an adequate firebreak will be burned out, just so certainly will we be destroyed, if we are not ready to meet armed invasion with armed resistance.

The board of directors of this Institute prepared at its June meeting resolutions endorsing the nation's defense program and placed at the disposal of our president the services of the Institute for use in carrying on that program. Those resolutions were published in the July ELECTRICAL ENGINEERING.

Many of our members are already engaged in direct service at Washington. Among these are Director Vannevar Bush and Past Presidents Gano Dunn, F. B. Jewett, W. H. Harrison, and John C. Parker.

Many members of the Institute and other engineers are directly engaged in defense preparedness activities at factories, where apparatus of all kinds is being made, and in the business of seeing that our power supply is adequate for every need. A roster of engineers and their abilities has been prepared so that when a need arises the right men to do a particular work can be quickly found. For preparedness against foes from the outside there is little more the engineer can do just at present. But without in any way changing his present occupation, he can do much to guard against dangers from within.

Soon our schools and colleges will open; football season will be upon us; and teams will battle for supremacy. Football is a great game requiring the strategy of defense as well as offense. The defense tactics, if well carried out, may keep the opponent from making a score, but the game can be won only by an offense strong enough to overcome the defense.

When two teams well coached and of like classification come together, only well-nigh perfect playing on the part of every man on the team can win a game; but it takes only one *saboteur* or one quitter on a team to ruin the defense and cause his team to lose. Fortunately, this does not happen often in a football game, because the coach soon benches such players and replaces them by men who will give their all.

I have no fears regarding damages to this country from without unless *saboteurs* and slackers from within are permitted to enjoy overly long the rights of citizenship, which they, through ignorance or with malice, proceed to pervert to selfish or other ignoble ends.

You may say, "What has all this to do with engineering and the activities of our Institute and what shall we do about it?"

My answer is it has everything to do with engineering and it is our business, before it is too late, to see to it that all foolish governmental and economic experiments are stopped. This is no new idea and, among engineers, there is little disagreement as to what we should do, but we are perhaps not quite so sure as to just how we shall do it.

I venture a few suggestions: First, we should continue to do our daily professional tasks as engineers, for, as I said, the engineer and his works have been our bulwark of defense, because his inventions and activities are offense plays of progress toward winning for civilization, as compared with losing to "jungle-ism." When a team is winning, its offense tactics always transcend all its defense tactics.

Next, we should enlarge our circle of activity to include the nonengineering phases of modern life. But you will say: "That is not news; we are already doing that. Lo, these many days we have besieged the officers of the Institute to include in our programs more papers and activities dealing with the nonelectrical and even nonengineering phases of our civilization." That the Institute has done with such success as to earn favorable comment and create a demand for more works of that type.

May we not, however, very well ask ourselves if after all such a course is the right one to pursue? As engineers and members of the Institute, may I again repeat, that it is our business to engineer; but is it not also our business to say *what* shall be engineered? Are we justified if we are employed to construct a dam, a power house, or a post office that is not needed, in just seeing that the work of building is well done? Are we just when we condemn the Administration at Washington and at the same time hold out our hands and ask Uncle Sam to do for our local city, county, or state that which we could do for ourselves?

Long ago we were told to "Render unto Caesar the things that are Caesar's and unto God the things that are God's". Perhaps if we bring into the program of our own American Institute of Electrical Engineers many other phases of social and civic administration, we shall only succeed in diluting our technical activities, salving our consciences, and locking in our hearts and minds things that will educate and stimulate us, but which held there will do little good to the world at large.

Is it superstition that makes engineers and other professional men feel that they should not step out of their laboratories and drop their slide rules for a time to become acquainted with the more emotional phases of life that control the actions of our people? Have we the right, especially in times like these, to sit by and let many of our great cities be operated under the rule of corrupt political machines? If you want to know about such a machine, read "These, Our Rulers" on page 1 of the September *Readers Digest*.

Henceforth, should we not devote all the time possible to know better those whom we would place in office and avoid so far as possible the election to office of men who lack all the proper requisites for the offices they expect to hold? Among those requisites we certainly have a right to expect honesty, character, evidence of success, as shown by ability for self-discipline, and achievement in one's chosen business or profession, supplemented by a thorough knowledge that can be attained only by long years of preparation for the office the candidate hopes to fill. If among the candidates up for election we cannot find such a man for whom to vote and work to elect to office, we should get new candidates—even if we have to prepare ourselves for the job to be done, give up engineering, and become candidates. After all, that may not be so bad—the names of George Washington and Leonardo da Vinci have not come down to us through the years because they were engineers.

I suggest that you *compare* for a moment the route the chief officers of service clubs, lodges, and societies, such as this, have to follow to be elected to office, with government election procedure, which permits a man after a doubtful career in one state to go to another state and be elected Governor, almost as soon as he has established legal residence.

I have no illusions that make me think an engineer per se, just because of his engineering training and ability, can step into governmental activities or even be just an intelligent voter; but I am certain that any engineer who can master the elements of his own profession, by the use of a reasonable amount of time and study can learn how to analyze what the problems of government are and propose for some of them reasonable solutions.

I would urge then that we do not try to bring all these things into our Institute, but that we project ourselves into the affairs of government through membership in organizations set up for that purpose, and that we go out more among our fellow citizens and tell them the advantages of the engineer's method of doing things. When the engineer makes a new design, he does not try to disregard all old designs, but he proceeds by a series of small changes in those things that have been found to operate well, to develop a better product. I was never more impressed with the value of such a procedure than during the last few weeks, a part of which I spent in making visits to manufacturing plants.

Those plants and those products at first glance seemed much the same as they were when I was a shop mechanic. But when I came to read the performance figures, compare weights of the products made, and note carefully the technique of the workmen, I soon discovered that the up-to-the-minute methods and products of 30, 20, 10, or even 5 years ago are now completely obsolete.

Some time ago my subject was announced as "Science and Superstition". At that time, I had in mind describing some of the philosophy that has grown up about the introduction of such words as electrons,

neutrons, uranium 235, and such, into our daily technical discourses. The events of the summer, however, have impressed upon me the fact that though it is still our business to engineer, we must adapt our engineering to the present needs of the nation, and one of those crying needs is more engineering method in our everyday nonengineering activities.

With that viewpoint, perhaps I have not been too far from my subject, for there is good Webster authority that "science" means "knowledge," whereas "superstitious" means "gullible or trustful".

I have not tried to entertain, and have not even said anything new. But if any thoughts I may have expressed prompt some person to enlarge his scope of activity so it will include finding ways for teaching the mass of our citizens to use more engineering methods in government, I shall feel well repaid.

Los Angeles Sets New Attendance Record for Pacific Coast Convention

TWICE in succession, now, Pacific Coast convention committees have succeeded in establishing new records for registration at a Pacific Coast convention. At the Ambassador Hotel in Los Angeles, Calif., the recent (August 27–30) 27th AIEE Pacific Coast convention closed with a total verified registered attendance of 465. By 11 this tops the figure set in 1938 at Portland, Ore. Various convention registration data are given in some detail in the accompanying tabulations.

Although the Los Angeles Section sponsored the second Pacific Coast convention to be held, back in 1911, and since has sponsored such meetings in 1919, 1924, 1929, and the annual summer convention in 1936, the 1940 convention was the first since 1919 to be held right in Los Angeles. Continuing a practice established in 1937, one of the sessions was held jointly with the Institute of Radio Engineers, which held its convention concurrently at the same hotel.

Twin features of the opening general session Tuesday morning, August 27, were an address by AIEE President R. W. Sorensen under the previously selected topic "Science and Superstition," and an address by Douglas Shearer, sound director for the Metro-Goldwyn-Mayer Studios, concerning "The Technology of Motion Pictures." Both these speakers effectively held the close attention of the approximately 200 persons who attended the opening session. Doctor Sorensen's stimulating message will be found elsewhere in this issue; through the collaboration of Douglas Shearer it is expected that the substance of his interesting address soon will be available for publication in ELECTRICAL ENGINEERING. AIEE Vice-President N. B. Hinson, general convention chairman, presided at the opening session, gave the official address of welcome, and introduced the speakers.

The program of technical sessions, including the student sessions, was carried out essentially in accordance with the details already published (*EE, Aug. '40, p. 332*).

Attendance at the various sessions ranged from about 30 to some 350 and averaged about 155. Attendance at the conference on governors, frequency control, and load swings, and at the two student technical sessions was about 50.

The communication session held jointly with the IRE Thursday morning, August 29, drew the heaviest attendance (350), including a very large proportion of AIEE conventioneers. Feature of that session was an address delivered by Major E. H. Armstrong of Columbia University, New York, N. Y., on the subject of his important radio development, frequency modulation for radiobroadcasting. Through the collaboration of Major Armstrong it is expected that a comprehensive article on this subject, embracing the substance of his Pacific Coast address, soon may be made available to the membership of the Institute through the columns of ELECTRICAL ENGINEERING. At the editor's suggestion, Major Armstrong has had this project under consideration for several months, but the pressure of developments incidental to securing adequate recognition and channel facilities for frequency-modulated broadcasting, coupled with recent exigencies of a military nature, have imposed a delay. Other features of the joint session included an address by R. F. Guy of the National Broadcasting Company on the subject of "Performance Characteristics of Frequency Modulation in Ultrahigh-Frequency Sound Broadcasting," and a demonstration discussion of "Frequency-Modulation Tests and Experiences," by M. B. Kiebert, Jr., of Jansky and Bailey Company. The length of this program and the absorbed interest of the audience required postponement of part of it to an adjourned session later in the day.

Presiding at the various technical sessions were the following, all of the Los Angeles Section: Protective Devices, E. W. Morris (A'29, M'35); Power Transmission and Distribution, Bradley Cozzens (A'28, M'38); Governor Conference, L. F. Hunt (A'21, F'38); Electrical Machinery, J. M. Gaylord (A'07, F'35); Instruments, Measurements, and Basic Sciences, Fred Garrison (A'22, M'29). F. E. Terman (A'23, M'34) presided at the joint communication session. The two student technical sessions were presided over respectively by James Bonner of the University of Utah and J. B. Possner of the University of Southern California.

A total of 16 technical papers, 5 addresses ranging from nontechnical to technical, and 10 student technical papers were presented exclusive of the informal discussions which characterized the governor conference.

CONFERENCE ON STUDENT ACTIVITIES

Continuing a long-established feature of Pacific Coast conventions, a joint conference of Student Branch counselors and Student Branch chairmen of Districts 8 and 9 and the western portion of District 10 was held Tuesday evening August 27. Also attending this conference were available Institute officers, past officers, and other interested persons who brought the total attendance to 52. This was a dinner conference, and the program itself was initiated by brief talks concerning the nature and significance of various Institute activities by National Secretary H. H. Henline, Editor G. R. Henninger, Vice-President A. L. Taylor (District 9), Vice-President H. W. Hitchcock (District 8), and President R. W. Sorensen. Doctor Sorensen urged engineering students to concentrate on "learning to do something useful and learning to do it well," suggesting that they base their selection of life work on aptitude and genuine interest and enthusiasm. He challenged engineering students to develop "some spirit of adventure and a determination to discover the many real frontiers and opportunities of our modern times."

Student chairmen described the features of Student Branch programs as conducted in the several schools represented and exchanged operating experiences in informal discussion. Problems and experiences relating to Branch activities were discussed by Branch counselors and others interested. The first part of the conference was presided over by Branch Counselor F. W. Maxstadt of California Institute of Technology, Pasadena, and the counselors' portion of the program was presided over by Branch Counselor S. G. Palmer of the University of Nevada, retiring chairman of the District 8 committee on student activities.

In executive session, the Student Branch counselors for District 9 elected Branch Counselor R. H. Hull of the University of Idaho to take office immediately as chairman of the District 9 committee on student activities, to take the place of Retiring Chairman A. L. Albert of Oregon State College. The counselors also took the following actions pertaining to District 9 Student Branch activities:

1. Voted to request permission to change the closing date for District student prize papers to June 15 for the academic year then closing, and to make it the direct responsibility of the District vice-president to see that corresponding District student prize awards are made at the immediately subsequent Pacific Coast convention.

2. Adopted the suggestion of Branch Counselor R. E. Lindblom of the University of Washington, Seattle, to undertake to prepare and circulate among the Student Branches of District 9 each

Analysis of Attendance at 1940 Pacific Coast Convention

Classification	Los Angeles	District 8*	District 9	District 10	Miscellaneous	Totals
Members	149	92	26	1	32	300
Men guests	14	6	6		3	29
Women guests	52	28	13		14	107
Enrolled Students	9	11	6		3	29
Totals	224	137	51	1	52	465

* Outside of Los Angeles Section territory.

Pacific Coast Convention Attendance—1920–1940

Year	Location	Attendance
1920	Portland, Ore.	251
1921	Salt Lake City, Utah	*
1922	Vancouver, B. C.	235
1923	Del Monte, Calif.	252
1924	Pasadena, Calif.	363
1925	Seattle, Wash.	408
1926	Salt Lake City, Utah	250
1927	Del Monte, Calif.	250
1928	Spokane, Wash.	250
1929	Santa Monica, Calif.	440
1930	Portland, Ore.	300
1931	Lake Tahoe, Calif.	247
1932	Vancouver, B. C.	300
1933	(No Pacific Coast convention)	
1934	Salt Lake City, Utah	232
1935	Seattle, Wash.	269
1936	Pasadena, Calif.	*
1937	Spokane, Wash.	266
1938	Portland, Ore.	454
1939	San Francisco, Calif.	*
1940	Los Angeles, Calif.	465

* Combined with summer convention.

January an "annual summary news letter" intended to contain brief summaries of the activities of each Branch for the preceding calendar year.

3. Voted to request the AIEE vice-president for District 9 to encourage all Sections in that District to continue the "committees on young men" instigated by Vice-President L. R. Gamble during his regime, and to continue the co-operative work between Sections and Branches.

Branch counselors for District 8 elected Professor C. F. Dalziel of the University of California, Berkeley, to assume office immediately as chairman of the District 8 committee on student activities to succeed Retiring Chairman S. G. Palmer of the University of Nevada. Professor J. C. Clark of the University of Arizona was elected secretary. Other matters were discussed, but no action taken.

YELLOWSTONE PARK CHOSEN FOR 1941

A joint-executive-committee luncheon meeting was held in the Spanish Room of the Ambassador Hotel Wednesday, August 28, presided over by Vice-President Hitchcock. A total of 26 persons was present, including President Sorensen, Vice-Presidents Hitchcock and Taylor, National Secretary Henline, Editor Henninger, and all available members of the executive committees of Districts 8 and 9. President Sorensen discussed current Institute problems and policies and reported upon significant actions that have been taken by the Institute's board of directors at recent meetings. Responding to the urgent invitation of the Montana Section, this group took action designating Yellowstone National Park as the location for the 1941 Pacific Coast convention. Differences of opinion as to whether that convention should be held early in August or late in August resulted in a decision to determine the definite date later after various factors have been considered. The San Diego Section filed a tentative invitation for the 1942 Pacific Coast convention to be held in San Diego incidental to the "Juan Cabrillo" celebration being planned for that year by San Diego in commemoration of its 400th year of settlement. Also, attention was called to the increased value that had been given to the various technical sessions of the convention by the program committee's procedure of accepting for presentation at the Pacific Coast convention only those technical papers that could be presented by the authors themselves. It was the consensus that the presence of the authors not only enhanced the value of the presentations but materially improved both the scope and value of resulting discussions.

CHARLES CROFT WINS FISKEN CUP

A generous program of entertainment features for both men and women was carried out in accordance with advance information previously published in ELECTRICAL ENGINEERING. Principal feature of the sports program was the annual golf tournament and competition for the John B. Fisken cup, which was held on the beautiful but rigorous course of the Riviera Country Club. A total of 40 persons played in the tournament.

Against a field of 31 qualified to compete for the John B. Fisken cup, two members of the Los Angeles Section, H. S. Warren (88 minus 15, 73) and Charles Croft (98 minus 25, 73), tied for first place in the John B. Fisken cup competition. These men elected to break the tie by tossing a coin rather than by playing an additional round, and Mr. Croft won the toss and became the 20th person to have his name engraved on the trophy. The John B. Fisken cup was procured in 1920 by the Portland Section, named in honor of John B. Fisken of Spokane, Wash., and presented as a trophy for annual competitions at Pacific Coast conventions. The three requirements governing competitions for the Fisken trophy are: first, that it may be won only by an active AIEE member in good standing affiliated with one of the Pacific Coast Sections (Los Angeles, San Francisco, Utah, Portland, Seattle, Vancouver, or Spokane); second, that the cup is a perpetual trophy, to be held by the winner of any tournament only until the winner of the next succeeding Pacific Coast convention tournament is declared; third, that competition shall be based upon 18-hole medal play. The following is a list of the 20 persons who have won the privilege of having their names engraved on the Fisken trophy:

1920—C. L. Wernicke, Portland
1921—C. P. Osborne, Portland
1922—J. B. Fisken, Spokane
1923—S. J. Lisberger, San Francisco
1924—K. E. Van Kuran, Los Angeles
1925—W. C. Heston, San Francisco
1926—P. M. Downing, San Francisco
1927—C. E. Heath, Los Angeles
1928—C. D. Luther, Seattle
1929—E. W. Rockwell, Los Angeles
1930—W. F. Hynes, Portland
1931—M. S. Barnes, San Francisco
1932—J. E. Underhill, Vancouver, B. C.
1934—H. W. Flye, San Francisco
1935—H. H. Schoolfield, Portland
1936—J. C. Henkle, Portland
1937—R. H. Dearborn, Corvallis
1938—T. S. Wood, Seattle
1939—L. J. Moore, San Francisco
1940—Chas. Croft, Los Angeles

Honors for first place in the women's putting contest were tied between Mrs. H. W. Hitchcock, and Mrs. J. K. Nunan, both of Los Angeles. Mrs. Hitchcock won on a draw.

The other formal competition was a tennis tournament, played on the Ambassador Hotel court. The singles tournament was won by Professor L. A. Pipes of Harvard University, with F. L. Goss of Los Angeles as runner-up. The winning doubles team was made up of Professor Pipes and H. W. Dunham of Los Angeles. A generous collection of prizes was provided by the sports committee.

Sections Committee Presents 1940 Survey of Local Activities

SUMMARIES of replies to 1940 questionnaires on Section activities were presented by the Sections committee at the conference of officers, delegates, and members held during the AIEE summer convention at Swampscott, Mass. Copies of the summaries which were in two parts, were distributed at the meeting. Part I, prepared by R. M. Pfalzgraff, is covered in the following discussion, and part II, prepared by W. B. Morton, is represented in the two accompanying charts.

In presenting these summaries the Sections Committee pointed out that benefits derived from any questionnaire sent to the Sections' executive committees depend largely on the mental stimulation and action motivated in each Section through subsequent studying and answering the survey. Thus, any summarizing at best can be only an anticlimax. Naturally, each Section has its own peculiar problems. No set rules can be devised to cover successful operation of every Section. The plan of execution in operating a small Section with a few members scattered over a large territory will not necessarily be suitable for a large Section with many members concentrated in a metropolitan area. Efficient and effective planning, the committee feels, must of necessity follow trial-and-error methods. For this reason, planning assistance is derived by studying and discussing the successes and failures of others.

The questionnaires were prepared for the Sections committee by C. A. Faust and circulated to 70 Sections of the Institute, including several recently formed Sections. Replies to part I were received from 61 Sections and to part II from 54 Sections, which the committee considers to be an excellent response.

SECTION TECHNICAL PRIZE PAPERS

National and District prize-paper contests are announced at a meeting by only 50 per cent of the Sections. However, 55 out of 61 Sections give members an opportunity to present papers at their meetings. One or two meetings per year are set aside for this purpose by 26 per cent of the Sections; 39 per cent have such papers presented as a supplement to regularly scheduled programs.

Approximately one-quarter of the Sections sponsor a technical-paper contest. The prizes range from $50 to $5, with the majority favoring first and second prizes of $15 and $10 respectively. National prize rules predominate.

Eleven Sections make special efforts to urge members to enter District competitions. Eight Sections report having tried contests in the past, but poor attendance and difficulty in securing contestants caused abandonment.

SECTION PAPERS ON POPULAR SUBJECTS

It is evident that the Sections schedule very few contests for papers on popular or semipopular subjects, since only two reported conducting such competitions. One Section operates a semitechnical contest under national rules with $15 and $10, first and second prizes respectively. The other conducts a popular-paper contest limited to Section members under 35 years of age, and supervised by the local convention committee. There are three prizes of $15, $10, and $5 respectively. Papers are rated on the basis of 40 per cent for the written paper, 40 per cent for oral presentation (as decided by appointed judges), and 20 per cent on audience vote.

STUDENT BRANCH ACTIVITIES

One or more joint meetings with Student Branches located in their territory, at which the students may present papers, are held by 46 per cent of the Sections. Another 22 per cent provide opportunities for such presentations in regularly scheduled meetings.

Student-paper contests are sponsored by 23 Sections, with prizes ranging from $20 to $5, including token awards. Generally, national rules prevail and a special Section committee co-operates with the Branch counselor in conducting these contests. It is interesting to note that 3 Sections report that the school authorities in their territory do not desire such contests.

Fifty-seven Sections report Student Branches located within their jurisdiction. Thirty Sections have one Student Branch, 13 have 2, 8 have 3, 5 have 4, one has 8. Such a diversification indicates many interesting problems.

Some Sections meet with students during their annual inspection trips; others arrange get-togethers with the Student Branches at luncheons; still others have created committees on student relations which co-operate with the Branch Counselors. Especially interesting is the arrangement whereby one Section encourages senior-class high-school students interested in electrical engineering to become local members of the Section.

TECHNICAL MEETINGS

Strictly technical meetings range from one to 20 per season with the majority favoring from 5 to 7. Some 61 per cent of these meetings are interspersed with the general meetings.

In 64 per cent of the Sections, either the program or the papers and meetings committee plans the technical meetings. The remainder use special committees, groups, or individuals for the purpose. Similarly, the Section chairman generally conducts the meeting although in particular cases a special-committee chairman may preside.

Presentation of papers by members occurs in 46 per cent of the Sections, ranging in frequency from all the meetings to one or two meetings per year. Most Sections favor the latter. Inspection trips are scheduled regularly by 54 per cent of the Sections, and occasionally by an additional 20 per cent. The selection of one theme for a season's technical meetings does not seem to be very popular, since only 3 Sections follow this procedure.

There is quite a diversification of opinion on how well the technical meetings are attended. However, 52 per cent of the Sections feel quite satisfied. Many Sections make use of special features to encourage attendance at technical meetings. These interesting procedures range from social periods and discussions following the meeting to dinners and bowling tournaments preceding.

RELATIONS WITH OTHER ENGINEERING SOCIETIES

Meetings with other engineering societies are quite popular with 71 per cent of the Sections that have sponsored such activities. In addition, more than 80 per cent consult other engineering organizations on scheduling to prevent conflicts in meeting dates.

Eighty-eight per cent of the Sections have their notices carried in other publications. The majority use the local newspapers; the remainder employ joint engineering society bulletins.

Considerable interest is indicated in having a large number of members—or Sections as a whole—affiliated with societies open to all types of engineers. Such joint relationships are reported by 40 Sections, or 65 per cent. However, only 24 per cent report Section financing of these affiliations.

SERVING OUTLYING GROUPS OF MEMBERS

Twenty-one Sections hold meetings in different localities so as to serve isolated groups of members. Only 5 Sections have formed divisions or sub-Sections, and only 2 report success on these ventures. Generally, the Section finances the mailing, meeting-room rental, and other incidentals of the sub-Section. Sub-Section chairmen are appointed by the Section chairmen, and basic planning is performed by the Section

SECTION ACTIVITIES

(54 SECTIONS REPORTING)

SECTION ACTIVITIES	ALABAMA	BOSTON	CENTRAL INDIANA	CHICAGO	CINCINNATI	CLEVELAND	COLUMBUS	DENVER	EAST TENNESSEE	ERIE	FLORIDA	FORT WAYNE	GEORGIA	HOUSTON	ITHACA	LEHIGH VALLEY	LOS ANGELES	LOUISVILLE
SECTION MEMBERSHIP	31	414	126	733	180	298	95	182	118	65	73	98	104	139	51	191	483	56
COMMITTEES																		
1. COMMITTEE ASSIGNMENT (NUMBER OF COMMITTEES)	3	4	4	11	9	10	2	6	4	3	2	3	3	11	2	10	8	6
2. SECTION REPRESENTED IN OTHER SOCIETIES OR CLUBS	X	X	X	X	X			X			X	X	X				X	
MEETING PUBLICITY																		
3. ISSUE SCHEDULE OF ALL MEETINGS EARLY IN SEASON			X	X		X				X				X		X		
4. INCLUDE ON NOTICE DETAILS OF NEXT MEETING	X	X	X	X	X	X	X			X					X	X		
5. MEETING NOTICES																		
PRINTED		X		X	X			X	X				X		X	X	X	
PHOTOLITHOGRAPHED												X	X					
MIMEOGRAPHED			X			X				X	X			X				X
HECTOGRAPHED	X						X		X									
6. NEWSPAPER PUBLICITY	X		X		X	X	X	X	X	X	X	X	X	X	X	X		X
SOCIABILITY																		
7. USE BADGES OR LAPEL TAGS AT MEETINGS					X	X	X				X			X		X	X	
8. MOVIE OR ENTERTAINMENT FEATURE TO START MEETING			X	X			X											
9. REFRESHMENTS AFTER MEETING	X					X	X			X	X			X	X			X
10. ATTENDANCE PRIZE										X		X				X		
11. WRITTEN OR TELEPHONE WELCOME TO NEW MEMBERS	X		X	X	X	X	X	X			X				X			X
12. NEW MEMBERS INTRODUCED AT MEETING	X		X		X		X		X	X	X	X				X		X
13. HAVE SOME PURELY OR LARGELY SOCIAL MEETINGS		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14. REGULAR SECTION LUNCHEONS	X										X		X					
GUESTS																		
15. GUESTS INVITED TO MOST MEETINGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
16. GUEST PRIVILEGE RETARDS SOME PROSPECTS JOINING				X	X					X								
17. LADY GUESTS INVITED TO GENERAL MEETINGS	X	X		X	X	X	X		X	X	X		X		X	X	X	X
BULLETINS ROSTERS REPORTS																		
18. NEWSLETTERS OR BULLETINS	X			X	X				X		X	X		X	X			
19. MEMBERSHIP ROSTER		X			X			X	X	X	X			X		X	X	
20. DISTRIBUTE ANNUAL REPORT		X	X											X				
21. YEAR BOOK									X	X						X		
22. SECTION HISTORY			X		X				X					X				
EDUCATIONAL ACTIVITY																		
23. SPONSOR EDUCATIONAL COURSES							X											
24. SPONSOR OTHER EDUCATIONAL PROGRAMS			X							X								X
EDUCATIONAL GUIDANCE																		
25. GUIDANCE TO HIGH SCHOOLS OR PREP SCHOOLS	X		X		X	X				X		X	X	X			X	
26. MAINTAIN LIST OF MEMBERS COLLEGES																		
EMPLOYMENT																		
27. SPONSOR EMPLOYMENT SERVICE		X	X	X	X			X			X							

SECTION ACTIVITIES	LYNN	MADISON	MANSFIELD	MARYLAND	MEMPHIS	MICHIGAN	MILWAUKEE	MINNESOTA	MONTANA	MUSCLE SHOALS	NEBRASKA	NEW ORLEANS	NEW YORK	NIAGARA FRONTIER	NORTH TEXAS	OKLAHOMA CITY	PHILADELPHIA	PITTSFIELD
SECTION MEMBERSHIP	145	65	64	224	61	358	270	89	39	46	56	97	3355	201	140	120	610	178
COMMITTEES																		
1. COMMITTEE ASSIGNMENT (NUMBER OF COMMITTEES)	10	2	5	6	5	8	5	3	2	3	-	4	13	2	4	8	13	11
2. SECTION REPRESENTED IN OTHER SOCIETIES OR CLUBS	X	X	X	X	X	X	X	X			X			X			X	X
MEETING PUBLICITY																		
3. ISSUE SCHEDULE OF ALL MEETINGS EARLY IN SEASON	X					X	X			X								X
4. INCLUDE ON NOTICE DETAILS OF NEXT MEETING	X		X	X								X	X	X	X	X		
5. MEETING NOTICES																		
PRINTED	X		X	X	X	X	X			X	X	X	X	X			X	
PHOTOLITHOGRAPHED						X							X					X
MIMEOGRAPHED		X	X					X							X	X		
HECTOGRAPHED									X									
6. NEWSPAPER PUBLICITY	X	X	X		X	X	X	X	X	X		X	X		X	X		X
SOCIABILITY																		
7. USE BADGES OR LAPEL TAGS AT MEETINGS								X								X		
8. MOVIE OR ENTERTAINMENT FEATURE TO START MEETING	X					X				X			X	X			X	
9. REFRESHMENTS AFTER MEETING		X	X	X			X		X		X	X	X	X			X	
10. ATTENDANCE PRIZE					X	X	X					X				X		
11. WRITTEN OR TELEPHONE WELCOME TO NEW MEMBERS	X		X	X		X			X	X	X	X		X	X		X	X
12. NEW MEMBERS INTRODUCED AT MEETING			X	X	X	X	X		X	X	X	X		X	X	X		
13. HAVE SOME PURELY OR LARGELY SOCIAL MEETINGS			X	X	X		X	X		X					X	X	X	X
14. REGULAR SECTION LUNCHEONS				X													X	X
GUESTS																		
15. GUESTS INVITED TO MOST MEETINGS	X	X	X	X	X	X		X	X	X	X	X	X		X	X	X	X
16. GUEST PRIVILEGE RETARDS SOME PROSPECTS JOINING			X											X				X
17. LADY GUESTS INVITED TO GENERAL MEETINGS	X						X	X	X	X		X	X			X		
BULLETINS ROSTERS REPORTS																		
18. NEWSLETTERS OR BULLETINS	X						X					X	X					X
19. MEMBERSHIP ROSTER			X			X			X	X		X			X			X
20. DISTRIBUTE ANNUAL REPORT	X																	
21. YEAR BOOK																		
22. SECTION HISTORY																		
EDUCATIONAL ACTIVITY																		
23. SPONSOR EDUCATIONAL COURSES	X												X				X	X
24. SPONSOR OTHER EDUCATIONAL PROGRAMS					X								X					X
EDUCATIONAL GUIDANCE																		
25. GUIDANCE TO HIGH SCHOOLS OR PREP SCHOOLS			X			X					X	X	X					X
26. MAINTAIN LIST OF MEMBERS COLLEGES			X			X												
EMPLOYMENT																		
27. SPONSOR EMPLOYMENT SERVICE						X					X		X				X	

SECTION ACTIVITIES	PORTLAND	PROVIDENCE	ROCHESTER	SAN ANTONIO	SAN FRANCISCO	SCHENECTADY	SEATTLE	SHARON	SOUTH CAROLINA	SPRINGFIELD	ST LOUIS	SYRACUSE	TORONTO	URBANA	VANCOUVER	VIRGINIA	WASHINGTON	WICHITA	TOTAL PARTICIPATING
SECTION MEMBERSHIP	151	91	95	43	486	403	153	86	-	60	268	71	338	77	107	94	332	46	
COMMITTEES																			
1. COMMITTEE ASSIGNMENT (NUMBER OF COMMITTEES)	6	3	8	3	6	10	4	6	5	4	4	-	8	1	2	3	7	2	
2. SECTION REPRESENTED IN OTHER SOCIETIES OR CLUBS	X	X	X	X	X	X	X			X	X	X	X			X	X		35
MEETING PUBLICITY																			
3. ISSUE SCHEDULE OF ALL MEETINGS EARLY IN SEASON			X				X				X	X			X			X	17
4. INCLUDE ON NOTICE DETAILS OF NEXT MEETING						X						X		X	X	X			23
5. MEETING NOTICES																			
PRINTED	X	X		X	X		X			X	X	X	X	X			X		32
PHOTOLITHOGRAPHED						X													6
MIMEOGRAPHED				X			X								X	X		X	16
HECTOGRAPHED								X											5
6. NEWSPAPER PUBLICITY	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	46
SOCIABILITY																			
7. USE BADGES OR LAPEL TAGS AT MEETINGS	X								X		X							X	13
8. MOVIE OR ENTERTAINMENT FEATURE TO START MEETING					X														10
9. REFRESHMENTS AFTER MEETING	X			X							X	X	X				X		24
10. ATTENDANCE PRIZE											X								9
11. WRITTEN OR TELEPHONE WELCOME TO NEW MEMBERS			X		X		X				X	X	X				X	X	30
12. NEW MEMBERS INTRODUCED AT MEETING	X			X	X			X				X	X	X	X	X	X	X	33
13. HAVE SOME PURELY OR LARGELY SOCIAL MEETINGS		X	X	X		X		X			X	X	X		X	X	X	X	39
14. REGULAR SECTION LUNCHEONS	X		X		X				X			X							11
GUESTS																			
15. GUESTS INVITED TO MOST MEETINGS	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	51
16. GUEST PRIVILEGE RETARDS SOME PROSPECTS JOINING										X									7
17. LADY GUESTS INVITED TO GENERAL MEETINGS	X		X			X	X	X		X		X	X	X					31
BULLETINS ROSTERS REPORTS																			
18. NEWSLETTERS OR BULLETINS			X		X	X													16
19. MEMBERSHIP ROSTER			X		X		X			X		X			X	X		X	24
20. DISTRIBUTE ANNUAL REPORT												X						X	6
21. YEAR BOOK		X	X									X						X	7
22. SECTION HISTORY						X												X	6
EDUCATIONAL ACTIVITY																			
23. SPONSOR EDUCATIONAL COURSES	X						X								X				8
24. SPONSOR OTHER EDUCATIONAL PROGRAMS			X																7
EDUCATIONAL GUIDANCE																			
25. GUIDANCE TO HIGH SCHOOLS OR PREP SCHOOLS			X			X							X				X		19
26. MAINTAIN LIST OF MEMBERS COLLEGES												X							3
EMPLOYMENT																			
27. SPONSOR EMPLOYMENT SERVICE												X							11

COMMITTEE ASSIGNMENTS

(54 SECTIONS REPORTING)
* INDICATES NO NUMBER FURNISHED

COMMITTEE	ALABAMA	BOSTON	CENTRAL INDIANA	CHICAGO	CINCINNATI	CLEVELAND	COLUMBUS	DENVER	EAST TENNESSEE	ERIE	FLORIDA	FORT WAYNE	GEORGIA	HOUSTON	ITHACA	LEHIGH VALLEY	LOS ANGELES	LOUISVILLE	LYNN	MADISON	MANSFIELD	MARYLAND	MEMPHIS	MICHIGAN	MILWAUKEE	MINNESOTA	MONTANA	MUSCLE SHOALS	NEBRASKA
SECTION MEMBERSHIP	31	414	126	733	180	298	95	182	118	65	73	98	104	139	51	191	483	56	145	65	64	224	61	358	270	89	39	46	56
ADVISORY BOARD						23						3		*				*			1								
AFFILIATED MEMBERSHIP																					4								
ARRANGEMENTS				*				3						4			4											5	
ATTENDANCE					5	12								8		9		*				5							
AUDITING														3		3													
BASIC EXECUTIVE																													
BASIC SCIENCE																													
BY LAWS														5															
COMMUNICATION				*																									
COMPETITIVE PROGRAM																													
CONTACT																								*					
COORDINATION					5																								
DINNER SPEAKERS					5																								
DISCUSSION																						6			3				
EDUCATION & BRANCHES														7				*					*						
EDUCATIONAL																													
EMPLOYMENT			1																										
ELECTRICAL MACHINERY																			*										
ENTERTAINMENT		16			5					2									*			7		*		2			
FINANCE																10													
HISTORICAL																5													
ILLUMINATION GROUP																													
IMPROVEMENTS OF MEMBERSHIP GRADE									4																				
INDUSTRIAL GROUP				*																									
INSTRUMENTS & MEASUREMENTS																			*										
JUNIOR ACTIVITIES					5																								
JUNIOR TECHNICAL SESSION																													
LAW																3													
LEGISLATION				*					4											1					1				
LOAN FUND																													
MEETINGS & PAPERS					5	9			5							17					7		*			5			
MEMBERSHIP	3	7	5	*	5	22	4	9		3	*	7	4	8	3	17	7	*	*	7	12	9	*	*	20	6	*	8	
MEMBERSHIP TRANSFERS				*		10		3									3						*	*	5				
MUSEUM OF SCIENCE & INDUSTRY				*																									
NOTIFICATIONS													4																
POLICY																													
POPULAR PROGRAM																													
POWER GROUP				*																									
PUBLIC UTILITIES																			*										
PROGRAM	3	6	4	*			4	9		3	*	4	3	8	3		5	*	*					*	5		*	4	
PUBLICITY				*	5	3		3						6		9		*	*				*	*					
PUBLIC RELATIONS														3															
PUBLIC SPEAKING																													
PUBLICATIONS																													
RECEPTION						5								6			6												
REGISTRATION OF ENGINEERS																						3							
RELATED ACTIVITIES																													
ROUND TABLE																								*					
RESEARCH																			*										
SECTION PRIZE PAPERS					5	3										3						3							
SOCIAL																													
STUDENTS GUIDANCE	3					1															4			*					
STUDENTS RELATIONS		7															3												
STUDENTS & YOUNG ENGINEERS				*																									
TECHNICAL PAPER REVIEW			2																										
TECHNICAL SESSIONS																													
TECHNICAL SUB-COMMITTEES						7		5											*										
TRANSMISSION & DISTRIBUTION																													
TRANSPORTATION																													
TRIPS																			*										
YEAR BOOK									5							4													
YOUNG MEN																													
TOTAL NUMBER OF COMMITTEES	3	4	4	11	9	10	2	6	4	3	2	3	3	11	2	10	6	6	10	2	5	6	5	8	5	3	2	3	*
TOTAL MEMBERS ON COMMITTEES	9	36	12	*	45	95	8	32	18	8	*	14	11	*	6	80	28	*	*	8	28	33	*	*	34	13	*	17	*

COMMITTEE	NEW ORLEANS	NEW YORK	NIAGARA FRONTIER	NORTH TEXAS	OKLAHOMA CITY	PHILADELPHIA	PITTSFIELD	PORTLAND	PROVIDENCE	ROCHESTER	SAN ANTONIO	SAN FRANCISCO	SCHENECTADY	SEATTLE	SHARON	SOUTH CAROLINA	SPRINGFIELD	ST. LOUIS	SYRACUSE	TORONTO	URBANA	VANCOUVER	VIRGINIA	WASHINGTON	WICHITA	TOTAL PARTICIPATING
SECTION MEMBERSHIP	97	3355	201	140	120	610	178	151	91	95	43	486	403	153	86	—	60	268	71	338	77	107	94	332	46	
ADVISORY BOARD																										5
AFFILIATED MEMBERSHIP																										1
ARRANGEMENTS								6				5														7
ATTENDANCE					15	3									4									5		10
AUDITING		3			3																					4
BASIC EXECUTIVE							6																			1
BASIC SCIENCE		3																								1
BY LAWS					3	1										3										4
COMMUNICATION		3				5		2		*						1										6
COMPETITIVE PROGRAM							11																			1
CONTACT																										1
COORDINATION									2				2													3
DINNER SPEAKERS																										1
DISCUSSION						7							2		4					1						6
EDUCATION & BRANCHES																										3
EDUCATIONAL		11					4			*			1													4
EMPLOYMENT												1														2
ELECTRICAL MACHINERY																										1
ENTERTAINMENT	7			11			12				1		1		4			3					*			15
FINANCE						4						3														3
HISTORICAL																										
ILLUMINATION GROUP		3																								1
IMPROVEMENTS OF MEMBERSHIP GRADE					8																					2
INDUSTRIAL GROUP						3										1										3
INSTRUMENTS & MEASUREMENTS						3																				2
JUNIOR ACTIVITIES																										1
JUNIOR TECHNICAL SESSION																								10		1
LAW																										1
LEGISLATION		*				3							2	3												8
LOAN FUND																				3						1
MEETINGS & PAPERS				8	10	6		7	4	*				8			8	10				3		4	*	19
MEMBERSHIP	8	19	2	12	12	20	5	11	4	*	5	5	1	7	6	3	14	12		2	1	3	*	10	*	51
MEMBERSHIP TRANSFERS						3				*			2					8		4						12
MUSEUM OF SCIENCE & INDUSTRY																										1
NOTIFICATIONS																										1
POLICY							5																			1
POPULAR PROGRAM							1																			1
POWER GROUP		12				3				*																4
PUBLIC UTILITIES																										1
PROGRAM	8	10	1				5	6			3	5	2		5	3				2						30
PUBLICITY	6	11		12			1			*			2		4		2			1				2		20
PUBLIC RELATIONS																										1
PUBLIC SPEAKING							1																			1
PUBLICATIONS					6															2						2
RECEPTION					10																					4
REGISTRATION OF ENGINEERS																	2						*			3
RELATED ACTIVITIES		11				12																				2
ROUND TABLE																										1
RESEARCH																										1
SECTION PRIZE PAPERS													1													5
SOCIAL										*																1
STUDENTS GUIDANCE		8																		1						6
STUDENTS RELATIONS							1					5												1		5
STUDENTS & YOUNG ENGINEERS																										1
TECHNICAL PAPER REVIEW																										1
TECHNICAL SESSIONS																								7		1
TECHNICAL SUB-COMMITTEES																										3
TRANSMISSION & DISTRIBUTION								1																		1
TRANSPORTATION		3																								1
TRIPS																										1
YEAR BOOK																										2
YOUNG MEN														5												1
TOTAL NUMBER OF COMMITTEES	4	13	2	4	8	13	11	6	3	8	3	6	10	4	6	5	4	4	*	8	1	2	3	7	2	
TOTAL MEMBERS ON COMMITTEES	29	*	3	43	67	73	52	33	10	*	9	24	16	23	27	11	26	33	*	16	1	6	*	39	*	

executive committee. In one instance the formation of a new Section has been reported as being the outgrowth of a sub-Section development.

It seems evident from the reports that either the memberships of the Sections are highly concentrated or a satisfactory solution to the problem of servicing isolated groups of members in the Section's territory has not yet been developed.

MEMBERSHIP AND TRANSFER TECHNIQUE

Most Sections depend on the membership committee for securing new members, encouraging Enrolled Students to become Associates, and getting present members to transfer to higher grades. A few Sections have special committees for this purpose and make membership drives. Only 3 offer prizes for membership activity. In 67 per cent of the Sections there are designated persons who determine whether a prospective member is qualified for membership or a member for transfer, before he is approached. The membership committee chairman functions in this capacity in a majority of the Sections.

In cases of negative action by the board of examiners, 21 Sections discuss the situation with the refused candidate, to prevent ill feeling toward the Institute. It should be noted that 27 Sections reported that none of their applicants had ever received such action. Several Sections request that all rejections be reported to the rejected candidate through the local membership committee and not direct. Several others propose that the transfer fee be waived to encourage transfers to higher grades because the response to their appeals for transfer is very poor.

LOCAL MEMBERSHIPS

This always has been a controversial subject. However, 53 per cent of the Sections have local members with dues ranging from \$1 to \$5 per year; \$2 to \$3 being the most popular. The Sections having the largest local memberships assess \$1.50 per year as local dues. Generally the only requirement is interest in the electrical field, although 2 Sections require that local members must have the qualifications for national membership. Only 4 Sections permit local members to hold office and 11 allow them to serve on committees. Twelve Sections, or 20 per cent, make a special drive for local members each year and plan popular lectures to appeal to them. Local memberships range from one to 1,400, but the ma-

Future AIEE Meetings

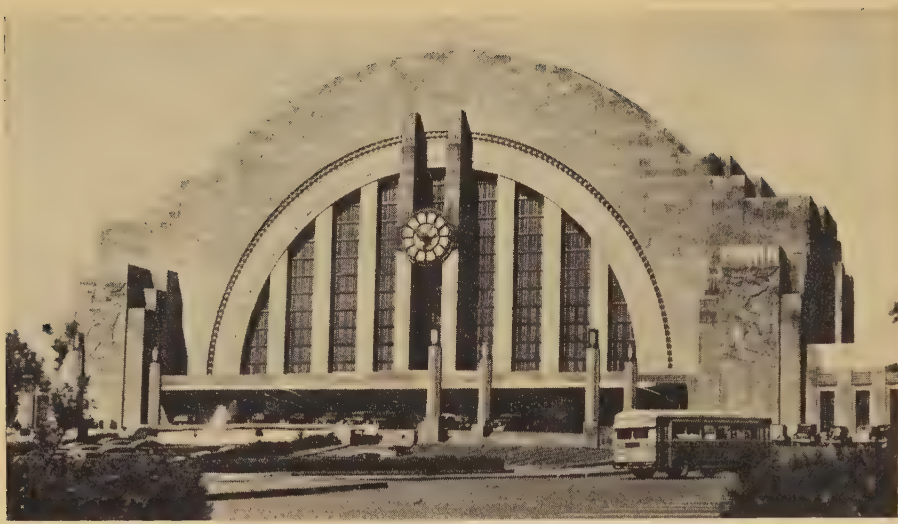
Middle Eastern District Meeting
Cincinnati, Ohio, October 9–11, 1940

Winter Convention
Philadelphia, Pa., January 27–31, 1941

Great Lakes District Meeting
Fort Wayne, Ind., April 1941

North Eastern District Meeting
Rochester, N. Y., May 1941

Summer Convention
Toronto, Can., June 16–20, 1941



Institute members traveling by railroad to the AIEE Middle Eastern District meeting at Cincinnati, Ohio, October 9–11, 1940, will arrive at the city's new $41,000,000 Union Terminal, shown here, which serves all roads

jority of Sections having local members have less than 75. Although reports range all the way from "complete dissatisfaction" to "outstanding success," the majority of the Sections having local members indicate that they are satisfied with the arrangement.

District

District 2 Prize Awards Announced

The AIEE Middle Eastern District (2) has announced District prize awards for papers presented in 1939. Student papers included in these awards must have been presented during the academic year ending June 30, 1939. Prizes awarded for 1939 papers by seven other Districts were announced in the July issue, pages 304–05.

District No. 2

Prize for best paper was awarded to F. A. Compton, Jr., for his paper "Application of Class B Insulation to Auxiliary-Type D-C Motors in Severe-Duty Service," presented at the Middle Eastern District meeting, Scranton, Pa., October 11, 1939.

Prize for initial paper was awarded to C. M. Sherer and K. J. Granbois for their paper "An Unusual Case of A-C Electrolysis on Single-Phase Power Cables," presented at a meeting of the Baltimore Section, May 15, 1939.

Prize for Branch paper was awarded to H. C. Robertson for his paper "Electricity in Medicine," presented at a meeting of the Johns Hopkins University Branch, March 10, 1939.

Prize for graduate student paper was awarded to Ellis F. King for his paper "Photoelectric Stress Studies of Objects in Motion," presented at a joint meeting of the University of Cincinnati Branch and the Cincinnati Section, May 1939.

Standards

Fuses Above 600 Volts. A new "Report on Standards for Fuses Above 600 Volts" has been prepared by the Institute's committee on protective devices. This report, which is a revision of the report issued in July 1936, is now out for letter ballot approval of the standards committee. These proposed standards apply to all types of fuses, whether for indoor or outdoor use, except fuses for 600 volts or below. In addition to the questions of rating, heating, dielectric tests, etc., covered in the 1936 report, sections have been added dealing with interrupting tests and time-current tests. The sections on general tests and on dielectric tests have been amplified considerably. The pamphlet report, No. 25, will be available shortly for purposes of suggestions and criticism. Copies may be obtained without charge.

Switchgear Assemblies. A revision of AIEE Standards No. 27, "Switchboards and Switching Equipment for Power and Light", issued in October 1930, has been developed by the committee on protective devices. This revision of No. 27, which will be entitled "Switchgear Assemblies", is to be issued as a report on a proposed revision of the present standard for a trial period of approximately one year. The proposed revision, now out to letter ballot of the standards committee, will come up for final approval at the October meeting of the standards committee. The new standard covers assemblies of switchgear devices, such as switches, interrupting devices, control, metering, protective, and regulating equipment, with associated interconnections and supporting structures. It does not apply to industrial control equipment, communication switchboards and switching equipment, or switchboards for shipboard. Copies of this new report, No. 27A, will be available for criticism and suggestion without charge.

Lightning Arresters. In addition to the two revised standards referred to in preceding items, the AIEE committee on protective devices has also developed a revision of the present AIEE Standards No. 28 on "Lightning Arresters". This revision is now out to letter ballot of the standards committee and will come up for final approval at the October meeting of the board of directors. It will supersede the present edition of No. 28 issued in 1936. The new standards apply to all types of lightning arresters which are designed for the protection of a-c power circuits and which have an element with nonlinear volt-ampere characteristic to limit the follow current. The new edition of No. 28 will be available at a cost of 30 cents per copy. AIEE members may obtain single copies at 50 per cent discount.

Revision of American Standard for Dry Cells Proposed. A complete reorganization of the sectional committee on dry cells and batteries, *C*18, is now under way. The new committee, which is under the sponsorship of the National Bureau of Standards, will undertake a revision of the specifications for dry cells and batteries approved as an American standard in 1937. The need for changes in these specifications has been brought about largely by improvements made in batteries and the new types required for use in portable radio sets.

Single-Phase Test Code. The preliminary draft of a proposed test code for single-phase machines has been completed by a special subcommittee of the AIEE committee on electrical machinery. The subcommittee, under the direction of C. C. Shutt, Westinghouse Electric and Manufacturing Company, has prepared this draft in co-operation with the committee on test code for fractional-horsepower motors. The new code is now being reviewed by the interested co-ordinating committees of the AIEE standards committee and will eventually come before the standards committee for approval and publication.

Translation of Standards Into Spanish. Consideration is now being given to the desirability of translating into Spanish a limited number of American standards covering electrical machinery and apparatus. The work of translation will probably be handled by the Department of Commerce and the standards to be translated will be those selected by industry as of greatest value. This work of translation is a revival of a similar undertaking carried out by the Institute in 1927 when seventeen AIEE standards were issued in Spanish.

Abstracts

TECHNICAL PAPERS are previewed in this section as they become available in advance pamphlet form. Copies may be obtained on payment of price indicated to the AIEE order department, 33 West 39th Street, New York, N. Y.

The papers previewed in this issue will be presented at the Middle Eastern District meeting, Cincinnati, Ohio, October 9–11, 1940.

Communication

40-161—A Push-Button-Tuned 50-Kw Broadcast Transmitter; *R. J. Rockwell and H. Lepple. 10¢.* This paper describes the use of automatic push-button tuning on short-wave broadcast transmitters that are

required to change from one frequency to another with the least possible interruption to programs. The tuning control circuits and the arrangement of the radio-frequency circuits of the transmitter are described.

Diathermy

40-149—Short-Wave Diathermy Apparatus and Frequency-Control Possibilities; *C. K. Gieringer (A'35). 10¢.* High-frequency currents are being used extensively in the medical field. Capacitive and inductive applicators are energized by self-excited oscillators. The wide range of patient circuit impedance under which these units operate often causes a considerable frequency shift of the oscillator. This paper analyzes some possibilities of limiting the frequency departure of short-wave generators caused by patient loading.

Domestic and Commercial Applications

40-154—Design Factors Involved in the Design of Domestic Motored Appliances; *L. C. Packer (A'25). 10¢.* In all domestic motored appliances, there are certain general design factors to which more detailed design factors are related, depending upon the appliance involved. In this paper the various design factors are enumerated and explained in a way which it is hoped will be of assistance to the many thousands of engineers engaged in the design of motored appliances. Curves show typical speed-torque characteristics of motors used to drive various types of appliances. Tables show the types of motors used with different types of appliances and the principal factors causing noise. General design factors involved in motored appliances are discussed as a group.

Electrical Machinery

40-151–ACO*—Single-Phase Motor Theory—A Correlation of the Cross-Field and Revolving-Field Concepts; *C. T. Button (A'26). 10¢.* Present methods of calculating the performance of single-phase induction motors are quite tedious, and probably do not convey to the mind of the practical engineer a logical concept of the operation of the motor such as is the case with generally used methods of polyphase-motor design calculation. It seems desirable to have a unified and co-ordinated theory for single-phase induction motors including formulas which are simplified as much as possible (with justifiable approximations) and which convey unabstruse concepts. The formulas in this paper may be used as the basis of a routine calculation procedure. In applying the equations developed, it would be necessary first to determine motor constants by established methods.

40-155–ACO*—A New Development in Wound-Core Distribution Transformers; *J. O. Fenwick (A'32) and D. E. Wiegand. 10¢.* Distribution transformers with round coils and a wound core have many desirable electrical characteristics and mechanical features that designers are constantly trying to obtain without increasing the transformer cost. A transformer made by winding a core and then winding the coils on the completed core not only has these desirable characteristics, but can be built economically. This paper outlines a new manufacturing technique for obtaining a round coil on a wound core without the requirement of radical changes in plant equipment. The wound core using the best grade of core steel in continuous-coil form permits a considerable change in the ratio of transformer losses without producing excessive exciting current. Round coils with low resistance and low reactance give better regulation at all power factors, and also high short-circuit capacity. The method of winding results in uniformly high impulse strength and long average life.

* Advance copies only; not scheduled for publication.

40-145–ACO*—Load-Regulating Transformer for a High-Voltage Loop; *E. H. Bancker (M'30), S. M. Hamill, Jr. (M'36), J. W. Hanson (M'33), and M. H. Sauter (A'25). 10¢.* This paper gives the reason for the installation of an angle-regulating transformer in a new 132-kv tie line that completes a loop between the Cincinnati Gas and Electric Company and the Indiana General Service Company, together with a description of the transformers involved and the relay protective system, both for the transformers and the interconnecting lines and busses adjacent thereto. To obtain information as to the performance of these proposed lines, representatives of the various systems involved made a study of the 132-kv and 66-kv network, existing and proposed, using as a tool an a-c network analyzer. The final choice of an angle-regulating transformer for this installation is a good illustration of how the network analyzer allows trying the effect of several possible alternatives in advance of purchase, thus enabling the selection of the best one.

40-159–ACO*—Large 3,600-RPM Induction Motors; *P. C. Smith (A'26). 10¢.* In the past four years, the company with which the writer has been associated has built more than 30,000 horsepower, in sizes ranging from 500 to 1,750 horsepower, of a new type 3,600-rpm induction motor. These motors are driving boiler feed pumps in central stations, descaling pumps in steel mills, and oil pumps throughout the petroleum industry. New distinctive features have been developed to increase the reliability and improve the performance. The operating characteristics show marked improvement over earlier designs. The motor has dual ventilation. The primary coil extensions are exceptionally well braced against radial and tangential movement. The bearings are lubricated by a force-feed system and by oil rings and are designed to prevent oil leakage. A patented rotor winding is superior to old designs both electrically and mechanically. Special emphasis has been placed upon the reduction of noise.

Industrial Power Applications

40-148—Fault-Voltage Drop and Impedance at Short-Circuit Currents in Low-Voltage Circuits; *O. R. Schurig (M'18). 10¢.* In the paper are presented new data on (1) arc-voltage drop and current-limiting effects for arc faults in bar-conductor structures, (2) current-limiting effect of insulated-cable arc faults, (3) cable impedance in an iron conduit, and (4) impedance of low-voltage switchgear circuit assemblies, derived from tests at short-circuit currents in circuits with open-circuit line-to-line voltages of 208–600 volts at 60 cycles. The currents ranged from less than 10,000 amperes to values as high as 100,000 amperes rms in some cases. The new data, supplementing existing impedance data, definitely indicate the possibility of reasonably accurate calculation of short-circuit currents in low-voltage circuits. The magnitude of fault currents actually obtained shows the fallacy of applying arbitrary and large discount factors to calculated short-circuit current values or of establishing arbitrary "maximum" values of current obtainable in low-voltage circuits and systems.

Instruments and Measurements

40-157—An Electrical Engine Indicator for Measuring Static and Dynamic Pressures; *E. J. Martin, C. E. Grinstead, R. N. Frawley. 10¢.* This paper presents the design of a capacitor-type indicator and associated electrical equipment, together with the technique of measuring pressures in internal-combustion engines. A small rugged indicator is described, which incorporates an efficient method of water cooling the frame and diaphragm. Small changes in indicator capacity are measured by a stable resonant circuit. This low-impedance circuit is easily shielded from electrical interference and has ample sensitivity for use with low-gain amplifiers. Cathode-ray and galvanometer oscillographs are used to record the output from the electrical circuits. A multielement galvanometer oscillograph is presented which introduces several desirable features. The technique of calibrating under engine operating conditions is discussed. A few illustrative indicator diagrams selected from thousands taken in the last few years are shown.

Power Transmission and Distribution

40-144—Some Insulator Designs Require Special Features to Insure Radio Quietness; *Charles J. Miller, Jr. (A'32). 10¢.* The suggested requirements for "radio-free" pin-type, switch and bus, and suspension insulators, if acceptable, indicate and justify from a factory-testing and production viewpoint, the following conclusions as regards existing standard designs:

1. For distribution voltages up to 4,400 or even 5,500 volts, the small one-piece pin-type insulators used require no "radio-proofing," even on solidly grounded pins.

2. If there are 6 to 12 inches of crossarm in series with small one-piece pin-type insulators on low-voltage distribution lines up to 13 kv, no "radio-proofing" is needed on the insulators.

3. Standard untreated pin-type insulators used on 17- to 69-kv distribution and transmission lines have radio-noise-influence voltages in the order of several thousand microvolts at a test potential about ten per cent above the usual line-to-ground voltages. "Radio-proofed" pin-type insulators, readily meeting reasonable requirements for freedom from radio interference, are available for use on lines in this voltage range.

4. Standard cemented pin-and-cap switch and bus insulators up to the 69-kv rating, with the exception

of the 66-*S*-class, readily meet the suggested requirements for freedom from radio interference without any special treatment; they are inherently quiet.

5. Standard switch and bus insulators for the 66-*S*-class and the 115-kv and higher-voltage classes may require precautions to meet the suggested abnormally low requirements. These insulators with slight changes can be made to meet these requirements readily.

6. Regular cemented pin-and-cap suspension insulators of modern manufacture readily meet the suggested requirements for freedom from radio interference; they are inherently quiet.

40-160—Developments in Carbon-Dioxide Fire-Extinguishing Systems and Application to Electrical Machinery and Equipment; *Eric Geertz. 10¢.* The development of low-pressure bulk storage and transportation facilities for liquid carbon dioxide has extended the scope of this material as a fire-extinguishing medium applicable to fire hazards in the electrical industry. Consideration is given to the theory of extinguishment and the physical characteristics of carbon dioxide. Original fundamental research, supplemented by experimental testing, has provided the necessary data for a solution of fire problems in outdoor hazards including transformer installations, and for a modified approach to indoor and enclosed hazards. New control equipment and cycle of operations have been developed to meet the needs of systems having a central supply of carbon dioxide which protect a variety of hazards. In conclusion, some typical examples are cited.

Power Generation

40-143—Increased Capacity and Interconnections of the Columbia Gas and Electric Corporation; *C. W. DeForest (F'36).* The territory served by the electrical properties of Columbia Gas and Electric Corporation include a major part of southwestern Ohio and a part of northern Kentucky across the Ohio River from Cincinnati. This paper presents a review of the development of the generating stations, interconnections, and transmission system of these properties. Particular reference is made to the modernization of the generating stations and the development of transmission and substations with a view toward prevention of outage to any major portion of the system. The solutions applied to prevent recurrence of outages caused by flood, bus faults, and system instability are presented.

Production and Application of Light

40-156—Radiant Heat—A Full-Fledged Industrial Tool; *Paul H. Goodell (A'40). 10¢.* Although the great majority of commercial heat sources deliver an appreciable portion of their energy in the infrared spectrum, most industrial heating processes now rely on heat transfer by convection. The ability of radiant energy to heat objects apparently without regard to the surrounding air temperature has been known to man since his first exposure to the sun. The wave lengths responsible for this phenomena have since been found to be those longer than visible radiation and because they are nearest the red end of the spectrum the name infrared or "near-red" has been applied. Infrared heating differs from other methods of heating primarily in that the energy is delivered directly from the source to the intended work in radiant form. Consequent convection from parts at elevated temperature is then a secondary rather than an intended result.

Protective Devices

40-158—A New Current-Limiting Fuse; *H. L. Rawlins (A'30), A. P. Strom (M'39), and H. W. Graybill (A'39).* Increasing concentration of power combined with the desire for more compact switchgear assemblies has created a demand for small, totally enclosed, high-interrupting-capacity fuses suitable for potential and operating transformer protection. The current-limiting fuse meets these requirements, for it is inherently a high-interrupting-capacity fuse of low current rating and can be totally enclosed in a small space. The theory and construction of previous current-limiting fuses are briefly described. The theory and construction of a new current-limiting fuse are given. The new fuse is simple in theory and construction. Its fundamental elements can be separated, studied, and tested, making it possible to predict an unusual degree of reliability and freedom from voltage surges. Test results confirm the reliability, high interrupting capacity, and freedom from voltage surges of the new fuse.

Safety

40-150—A Comparison of the Relative Efficiency of the Schafer and Pole-Top Methods of Artificial Respiration; *W. B. Kouwenhoven (F'34), D. R. Hooker, and O. R. Langworthy. 10¢.* The pole-top method of artificial respiration was devised to give prompt aid in case of electric shock occurring while men are working on poles of power lines. The results obtained with this method were excellent, and in 1939 14 successful resuscitations out of 16 applications were reported. This is an exceptionally fine record when compared with the reports of cases where artificial respiration was not started until the victims had been lowered to the ground. A comprehensive study of the pole-top method was started in the fall of 1939 at The Johns Hopkins University. This paper presents a report of the first stage of the investigation and deals only with a comparison of the relative amounts of air moved by the standard Schafer prone-pressure method, the modified Schafer method, and the pole-top method.

Personal . . .

A. W. Berresford (A'94, F'14) retired managing director of the National Electrical Manufacturers Association, New York, N. Y., has been appointed chairman of the AIEE committee on Institute policy for 1940–41. Born at Brooklyn, N. Y., July 9, 1879, he received the degree of bachelor of science in electricity from Brooklyn Polytechnic Institute in 1892 and that of mechanical engineer from Cornell University in 1893. He was employed successively by the Brooklyn City Railroad Company as electrician, by H. B. Coho and Company, New York, N. Y., on sales, and by the Riker Electric Company as designer. From 1896 to 1898 he was in charge of design for the Ward-Leonard Electric Company. In 1898 he became one of the organizers of the Iron-Clad Resistance Company, of which he became vice-president. The assets of the company were purchased by the Cutler-Hammer Company, Milwaukee, Wis., in 1900, and Mr. Berresford was employed in the engineering department of the latter organization. He became superintendent in 1901 and vice-president and general manager in 1905, continuing in the latter position until 1923. He was vice-president of the Electric Refrigerator Corporation 1925–27, and from 1929 until his retirement in 1934 was managing director of the NEMA. He was a manager of the Institute 1909–12, vice-president 1912–14, and president 1920–21. He has served on the Edison Medal committee, Sections committee (chairman 1921–24), meetings and papers committee, standards committee, and committee on safety (chairman 1929–31), and has represented the Institute on American Engineering Council, the John Fritz Medal board of award, electrical committee of the National Fire Protection Association, National Fire Waste Council, National Safety Council, and United Engineering Trustees, Inc. He has been a member of the committee on Institute policy since 1934 and was a member of the committee on public policy 1923–26. He is also a member of the committee on planning and co-ordination and a representative on the Hoover Medal board of award. He is a past president of AEC and is also a member of The American Society of Mechanical Engineers, the Society of Naval Architects and Marine Engineers, and the Franklin Institute.

F. M. Farmer (A'02, F'13) vice-president and chief engineer, Electrical Testing Laboratories, New York, N. Y., and junior past president, AIEE, has been appointed chairman of the AIEE committee on planning and co-ordination. Born March 28, 1877, at Ilion, N. Y., he received the degree of mechanical engineer from Cornell University in 1899. After 18 months in the testing department of General Electric Company, Schenectady, N. Y., and two years as inspector in the United States Navy Yard at Brooklyn, N. Y., he joined the staff of Electrical Testing Laboratories (then called the Lamp Testing Bureau). He became engineer in 1906, chief engineer in 1912, and vice-president in 1929. He has been especially active in standardization work, with the American Society for Testing Materials, of which he is a past president, American Standards Association, United States National Committee of the International Electrotechnical Commission, and American Society of Mechanical Engineers. He was a director of the Institute 1934–38, vice-president 1938–39, and president 1939–40. He is also a member of the executive and finance committees and an Institute representative on the John Fritz Medal

F. M. FARMER

A. E. KNOWLTON

FRANK THORNTON, JR.

Bachrach

A. W. BERRESFORD

C. A. POWEL

board of award, Engineering Foundation board, Engineering Societies Monographs committee, and United Engineering Trustees, Inc. He was chairman of the committee on planning and co-ordination 1938–39 and has also served on the following committees: standards, power transmission and distribution, electric welding, research (chairman 1933–36), award of Institute prizes, Edison Medal, headquarters (chairman 1936–38), Institute policy, and transfers, and on the board of examiners.

A. E. Knowlton (M'17, F'30) associate editor, *Electrical World*, McGraw-Hill Publishing Company, New York, N. Y., has been appointed chairman of the AIEE board of examiners for 1940–41. He has been a member of the board since 1937. He is also a member of the committees on industrial power applications on instruments and measurements, of which he was chairman 1924–27, and formerly served on the following committees: meetings and papers (chairman 1929–31), award of Institute prizes (chairman 1929–31), co-ordination of Institute activities, publication, Edison Medal, transportation, electrochemistry and electrometallurgy, economic status of the engineer. He was born February 16, 1886, at New Haven, Conn., and received the degrees of bachelor of science (1910) and master of science (1912) from Trinity College, and that of electrical engineer (1921) from Yale University. He was instructor in mathematics and physics at Trinity College, Hartford, Conn., 1910–14, and assistant professor of physics 1914–19. From 1919 to 1930 he was a member of the department of electrical engineering at Yale University, New Haven, Conn., as instructor, assistant professor, and associate professor. He became associate editor of *Electrical World* in 1930. From 1910 to 1929 he was also a member of the staff of the Connecticut Public Utilities Commission and served in 1918–19 as deputy administrative engineer of the United States Fuel Commission, and in 1924 on the engineering advisory board of the Department of Commerce Northeast superpower committee. He has also carried on general consulting practice, is the author of a book and a number of articles and editor of the "Standard Handbook for Electrical Engineers", and has been active on the International Electrotechnical Commission and the former National Electric Light Association. He is a member of Sigma Xi.

Frank Thornton, Jr. (A'10, F'21) engineering manager, association activities, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been appointed chairman of the AIEE committee on safety for the year 1940–41. He has been a member of the committee since 1931 and is also a member of the committee on domestic and commercial applications and Institute representative on the National Fire Waste Council. Born July 10, 1886, at St. Joseph, Mo., he received the degree of bachelor of science in electrical engineering from the University of Missouri in 1908, and later did graduate work at the Technische Hochschule at Charlottenburg, Berlin, Germany. In 1909 he entered the student course of the Westinghouse company at East Pittsburgh. He was made section engineer in charge of electric heating engineering in 1914, and in 1918 was made chief engineer of the company's subsidiary at Mansfield, Ohio, also continuing in charge of electric heating engineering at East Pittsburgh. He was transferred to East Pittsburgh in 1922, and again to Mansfield in 1925, and in 1927 became manager of engineering for the merchandising department. He returned to East Pittsburgh in 1930 as general engineer in domestic engineering, and assumed his present position in 1931. He holds a number of patents, mostly for electric heating appliances. He is also a member of The American Society of Mechanical Engineers, a member of the standards council and electrical standards committee of the American Standards Association, vice-chairman of the codes and standards committee of the National Electrical Manufacturers Association, member of the United States National Committee of the International Electrotechnical Commission, and active on other co-ordinating bodies.

C. A. Powel (M'20) manager, industry engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., who was appointed chairman of the AIEE Charles LeGeyt Fortescue Fellowship committee on its formation in January 1940, has been reappointed for the year 1940–41. He was born at Rouen, France, July 29, 1884, and graduated as electrical engineer in 1905 from Bernese Technical College, Burgdorf-Bern, Switzerland. He then entered the engineering department of Brown Boveri and Company, Baden, Switzerland, and in 1910 was appointed section engineer in charge of hydroelectric plants. In 1911 he was sent as technical representative to Japan, continuing in that work until 1915, when he entered military service. From 1916 to 1919 he was with the British War Mission in the United States, inspecting war materials. After the dissolution of the Mission in 1919 he joined the central-station division of the general engineering department of the Westinghouse company. Later he became manager of the central station engineering department, and when the industry engineering department was established in 1938 he was made its manager. He was a director of the Institute 1936–40, and is a past chairman of the Pittsburgh Section. He is a member of the committee on constitution and bylaws, the Lamme Medal committee, standards committee, and committee on electric welding, and formerly was a member of the committees on power generation, electrochemistry and electrometallurgy, and applications to marine work. He is a member also of the American Society of Mechanical Engineers and the Institution of Electrical Engineers of Great Britain.

E. A. Baldwin (A'07) has retired as vice-president and European manager of the International General Electric Company. Born at Hyde Park, Mass., May 7, 1874, he received the degree of bachelor of science from Massachusetts Institute of Technology in 1896. He entered the test course of General Electric Company, Schenectady, N. Y., in 1896, was transferred to the railway engineering department in 1898, and later the same year to the foreign department. He was made assistant manager of the foreign department in 1912 and in 1919 manager of the department of Europe, later becoming manager of the Schenectady office of International General Electric. He went to Paris, France, in 1927 as general European manager, and was made a vice-president the following year. He served as president of the American Chamber of Commerce in France and in 1939 was awarded that organization's gold medal for distinguished service. He was also made an officer of the Legion of Honor by the French Government. He was appointed observer for the United States Government at the International Labor Conference in Geneva, Switzerland, in 1934, and was also active in the International Chamber of Commerce.

R. H. Manson (A'02, M'18) formerly vice-president and chief engineer of Stromberg-Carlson Telephone Manufacturing Com-

pany, Rochester, N. Y., was recently made vice-president and general manager of the company. A native (1877) of Bath, Maine, he received the degrees of bachelor of mechanical engineering in electrical engineering (1898), electrical engineer (1901), and doctor of engineering (1933) from the University of Maine. He was an assistant in the electrical-engineering department at the University of Maine, Orono, 1898–99, and assistant in the telephone laboratory of Western Electric Company, Chicago, Ill., 1899–1900. From 1900 to 1904 he was with the Kellogg Switchboard and Supply Company, Chicago, as laboratory assistant and sales engineer. He became assistant chief engineer for the Dean Electrical Company, Elyria, Ohio, in 1904, later becoming sales manager, and in 1912 chief engineer. He continued as chief engineer for the Dean company and its successor, the Garford Manufacturing Company, until 1916, when he joined Stromberg-Carlson as chief engineer. He holds many patents on telephone and automobile equipment and is the author of a number of technical articles. He is also a member of the Society of Automotive Engineers and a past president of the Institute of Radio Engineers. **F. C. Young** (A'24, M'30) formerly manager of engineering, Stromberg Carlson Telephone Manufacturing Company, was made chief engineer. A native (1899) of Rochester, N. Y., and an electrical-engineering graduate, he has gained his entire professional experience with Stromberg-Carlson. He was employed by the company in 1922 as an engineer in the electrical laboratory, later becoming development engineer, and manager of engineering. He has been active in the AIEE Rochester Section and in committee work for the National Electrical Manufacturers Association.

M. S. Coover (A'16, M'32) professor and head of the department of electrical engineering, Iowa State College, Ames, and director of the Institute, has been appointed chairman of the AIEE Sections committee for 1940–41. He has been a member of the committee since 1937. He is a member also of the committees on education and on planning and co-ordination. A biographical sketch of Professor Coover in connection with his nomination to membership on the board of directors appeared in the March issue, page 133.

H. W. Bibber (A'21, M'30) professor of electrical engineering, Ohio State University, Columbus, has been appointed chairman of the AIEE committee on Student Branches for the year 1940–41. He has been a member of the committee since 1939, and is also a member of the committee on education and a former member of the committee on power transmission and distribution. Born March 12, 1899, at Gloucester, Mass., he graduated in electrical engineering at Massachusetts Institute of Technology in 1920, and later carried on advanced study there and at the University of Paris. He was exchange instructor from MIT to the École Centrale des Arts et Manufactures, Paris, France, 1920–21, and instructor in electrical engineering at MIT, Cambridge, Mass., 1921–23. He became an office engineer on apparatus sales for International General Electric Company, Schenectady, N. Y., in 1923, and the following year was sent as sales engineer to Tokyo, Japan. In 1926 he was made manager of the Osaka, Japan, office of the company, and in 1927 was transferred back to Schenectady as office engineer in charge of Russian business. From 1929 to 1931 he was application engineer, central station department, General Electric Company. He went to Ohio State University as associate professor of electrical engineering in 1932, later becoming full professor, and has also carried on consulting engineering practice. He is also a member of Tau Beta Pi, Société Française des Électriciens, and Society for the Promotion of Engineering Education, and is the author of articles on engineering education, and on technical and other subjects.

D. M. Simmons (A'22, F'28) vice-president and director, General Cable Corporation, New York, N. Y., has been appointed chairman of the Institute's publication committee for 1940–41. He has been a member of the committee since 1935, and was vice-chairman from April to August 1940. He also is a member of the technical program committee and the committees on planning and co-ordination, award of Institute prizes, and power transmission and distribution and was chairman of the last-named 1933–35. A biographical sketch of Doctor Simmons appeared in the March issue, page 134.

J. H. Lampe (A'20, M'26) professor and head of the department of electrical engineering, University of Connecticut, Storrs, has been appointed dean of engineering of the University. Born at Baltimore, Md., December 1, 1896, he graduated from Baltimore Polytechnic Institute in 1915 and received the degrees of bachelor of science in engineering, 1918, master of electrical engineering, 1925, and doctor in electrical engineering, 1931, from Johns Hopkins University. After spending a year and a half in the research laboratory of the Winchester Repeating Arms Company, New Haven, Conn., he became an instructor in electrical engineering at Johns Hopkins University, Baltimore, Md., in the fall of 1920. He became an associate in electrical engineering, in 1927, and associate professor in 1929, continuing in that position until 1938, when he was appointed head of the electrical-engineering department at the University of Connecticut. In addition to his work at Johns Hopkins he was employed by the Chesapeake and Potomac Telephone Company, Washington, D. C., and by Consolidated Gas Electric Light and Power Company of Baltimore at various times in charge of employee training courses, and also organized and operated for two years the Homewood Electric Company, and carried on private consulting practice.

L. G. Woodford (M'31) plant operation engineer, American Telephone and Telegraph Company, New York, N. Y., has been appointed assistant vice-president. He will co-ordinate the work of the plant operation, traffic, and operating results divisions of the operations and engineering department. Born August 10, 1888, at Waterloo, Iowa, he studied mining engineering at Iowa State College. He was employed by the Iowa Telephone Company in 1911 as engineering assistant, becoming appraisal engineer in 1914. In 1916 he was made appraisal engineer for Northwestern Bell Telephone Company, and in 1921 engineer of costs and practices. He came to the American Telephone and Telegraph Company in 1923 to carry on special studies. In 1927 he became plant inventory and costs engineer, in 1933 plant extension engineer, in 1937 operating results engineer, and in 1939 plant operation engineer.

D. E. Noble (A'32) assistant professor of engineering, University of Connecticut, Storrs, has been granted a two-year leave of absence to head the research department of Galvin Manufacturing Company, Chicago, Ill., specializing in the development of communications equipment in relation to national defense. Born October 4, 1901, at Naugatuck, Conn., he received the degree of bachelor of science from Connecticut Agricultural College (now University of Connecticut) in 1928. He became a lecturer at the College in 1926, instructor in mathematics and mechanical engineering in 1928, and assistant professor of mechanical engineering, in charge of the electrical-engineering laboratory and teaching electrical-engineering subjects, in 1931. The next year he was made director of the college broadcasting station, which he had first designed in 1922 and redesigned to keep pace with developments. Lately he has been active in frequency-modulation development. He is also a member of the Institute of Radio Engineers.

M. S. COOVER

H. W. BIBBER

Bachrach

D. M. SIMMONS

O. C. BRILL

F. M. FEIKER

R. T. HENRY

O. C. Brill (A'08, M'20) engineer, general engineering staff, American Telephone and Telegraph Company, New York, N. Y., has been appointed chairman of the Institute's membership committee for 1940–41. He was born October 28, 1884, at Pentwater, Mich. From 1906 to 1910 he was engaged in pioneer radio engineering on the Pacific Coast, with the American De Forest Wireless Telegraph Company, United Wireless Telegraph Company, and De Forest Radio Telephone Company, for the latter two companies as Pacific Coast engineer, installing stations on ships and on shore. In 1910 he entered the employ of the Bell System, as a student engineer with the Pacific Telephone and Telegraph Company, San Francisco, Calif. He became district plant engineer for the Spokane, Wash., district, and later for the Oregon district, with headquarters at Portland. During 1918 and 1919 he served in the United States Army, becoming a major in the Signal Corps, and now holds the rank of lieutenant-colonel in the Signal Corps Reserve. Since 1920 he has been on the general engineering staff of the American Telephone and Telegraph Company, New York, N. Y. He has been a member of the membership committee since 1938, and was formerly chairman of the membership committee of the New York Section.

F. M. Feiker (M'34) dean of the school of engineering, George Washington University, Washington, D. C., has been appointed chairman of the Institute's committee on economic status of the engineer for the year 1940–41. He has been a member of the committee since 1937, and formerly was a member of the committee on production and application of light. A biographical sketch of Doctor Feiker, who was executive secretary of American Engineering Council 1934–40, appeared in the February issue, page 89.

R. T. Henry (A'24, F'33) electrical engineer in charge of design, Buffalo, Niagara, and Eastern Power Corporation, Buffalo, N. Y., has been appointed chairman of the AIEE committee on standards for the year 1940–41. He has been a member of the committee since 1936, and is also a member of the committee on planning and co-ordination and of the committee on protective devices, of which he was chairman 1932–34. He was born November 17, 1889, at Stronghurst, Ill. He was employed as draftsman by General Electric Company, Lynn, Mass., 1908–09, and by the Niagara Falls Hydraulic Power and Manufacturing Company, Niagara Falls, N. Y., 1909–12. Following short periods as an assistant electrical engineer for the Hooker Electro chemical Company, Niagara Falls, and designing draftsman for the Edison Illuminating Company, Detroit, Mich., he became assistant superintendent of the Niagara Electric Service Corporation, Niagara Falls, in 1914. In 1918 he became assistant electrical engineer of the Niagara Falls Power Company, and in 1929 was appointed to his present position with the parent company.

F. D. Newbury (A'07, F'21) formerly manager of the new products division, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been appointed manager of the company's newly created emergency products division, organized to produce defense equipment under the Government preparedness program. Born June 9, 1880, at Brooklyn, N. Y., he received the degree of mechanical engineer at Cornell University in 1901, and has been with the Westinghouse company ever since in various positions. Before becoming manager of the new products division in 1938 he was economist and assistant to vice-president. He was a director of the Institute 1918–22.

E. B. Webb (A'24, M'34) has retired as building and equipment engineer, Indiana Bell Telephone Company, Indianapolis. Born in Johnson County, Ind., January 4, 1883, and educated in Anderson, Ind., he entered the employ of the Central Union Telephone Company, Indianapolis, in 1911, as equipment installer, becoming inspector in the engineering department in 1914, and assistant equipment engineer in 1916. During 1917–18 he was equipment engineer for the Central Union Telephone Company and Indiana Bell Telephone Company, in charge of equipment for the state of Indiana. He had been buildings and equipment engineer for the latter company since 1926.

L. W. Germain (A'21) formerly general plant superintendent, western, American Telephone and Telegraph Company, Chicago, Ill., has been appointed general plant manager. **G. G. Jones** (M'35) formerly general plant superintendent, southern, St. Louis, Mo., has been made general plant superintendent, western, Chicago. **G. S. Dring** (A'21, M'32) formerly division plant superintendent, Atlanta, Ga., has been made general plant superintendent, southern, St. Louis. **H. T. Killingsworth** (A'23, M'30) formerly division plant superintendent, Colorado, Denver, Colo., has been appointed general plant supervisor.

A. D. Brown (A'31) district manager, Allis-Chalmers Manufacturing Company, Los Angeles, Calif., has been elected second vice-president of the Los Angeles Electric Club for 1940–41. **C. P. Garman** (A'23, M'26) assistant engineer, Los Angeles Bureau of Power and Light, has been elected third vice-president. **H. W. Tice** (A'34) assistant manager of operations, Southern California Edison Company, Los Angeles, has been elected to the executive committee of the club.

Obituary • • •

Louis Aloysius Ferguson (A'01, M'04, F'12, *past president*) retired vice-president, Commonwealth Edison Company, Chicago, Ill., died August 25, 1940. He was born at Dorchester, Mass., August 19, 1867, and graduated in electrical engineering from Massachusetts Institute of Technology in 1888, with the degree of bachelor of science. He entered the employ of the Chicago Edison Company in 1888 and the following year was appointed chief electrical engineer. In 1893 he was also put in charge of the contract department, and in 1897 was made general superintendent of the Chicago Edison Company and the Commonwealth Electric Company. He was elected second vice-president of the two companies in 1902, and when they consolidated as Commonwealth Edison Company in 1907, he continued in that position, becoming vice-president in 1914. He retired December 31, 1935. He was a manager of the Institute 1904–07, vice-president 1907–08, and president 1908–09, and was also a past president of the Association of Edison Illuminating Companies and the former National Electric Light Association, and a member of the Illuminating Engineering Society and the Western Society of Engineers.

Alvin Leslie Powell (A'13, F'26) supervising engineer, lamp department General Electric Company, New York, N. Y., died August 21, 1940. He was born April 6, 1889, at Brooklyn, N. Y., and received the degree of electrical engineer at Columbia University in 1910. The same year he entered the test course at the Edison Lamp Works of General Electric Company at Harrison, N. J. From 1911 to 1924 he was assistant to the illuminating engineer. In 1924 he was sent to Europe as a special representative of International General Electric Company working on illumination problems. He served as delegate of the United States Committee to the International commission on Illumination at Geneva in 1924 and member of the United States Commission to the Paris Exposition, 1925. Returning to the United States in 1925 he became manager of the engineering

department of the Edison Lamp Works. When the Edison and the National Lamp Works were consolidated in 1932 as the lamp department of General Electric, and the Harrison group transferred to Nela Park, Cleveland, Ohio, an eastern office of the engineering department was formed and Mr. Powell placed in charge. He also conducted courses in illumination at the Columbia University School of Architecture, and the New York University College of Engineering, and was the author of many papers and articles on lighting. He was a member of the AIEE board of examiners (chairman 1939–40) and of the committee on production and application of light (chairman 1936–37), a past president of the Illuminating Engineering Society, and a member of Sigma Xi.

Leslie Robert Hicks (A'12, M'28) consulting engineer, Springfield, Mass., employed by Gibbs and Hill, New York, N. Y., died August 29, 1940. He was born October 4, 1880, at Port Henry, N. Y., and received the degree of bachelor of arts from Brown University in 1903. After a year in the test department of General Electric Company, Schenectady, N. Y., he was in charge of the lighting department of the Elgin, Aurora, and Chicago Railroad Company, Elgin, Ill., from 1904 to 1908. He then became superintendent and electrical engineer of the Fall River (Mass.) Electric Light Company. In 1914 he joined Charles H. Tenney and Company, Boston, Mass., as assistant electrical engineer, becoming electrical engineer in 1918. He left the company in 1928 to become electrical engineer of the South American properties of Electric Bond and Share Company. Returning after a year in Brazil, he joined M. J. Daley and Company, Springfield, Mass., and later was a member of the engineering staff of the Western Massachusetts Companies, Springfield. In recent years his time had been divided between private consulting practice and work for Gibbs and Hill. For that company he supervised laying high-voltage underground cable and conduit systems in connection with the electrification of the Pennsylvania Railroad in Washington, D. C., and Baltimore, Md.

Eivind Styff (A'23, M'31) chief electrical engineer, power-plant department, Aktieselskapet Norsk Elektrisk and Brown Boveri, Oslo, Norway, died recently, according to information just received. He was born June 22, 1894, at Alten, Norway, and graduated from the Technical University of Norway in 1915. Following graduation he entered the employ of Norsk Elektrisk and Brown Boveri as a designer in the department of power-plant engineering. He was made engineer in charge of the department in 1918. From 1923 to 1925 he was employed as design draftsman and checker by Pacific Gas and Electric Company, San Francisco, Calif. He returned to Norsk Elektrisk and Brown Boveri in 1925 as electrical engineer in charge of power-plant engineering, and was later given the title of chief electrical engineer of the department. He was also a member of Norsk Ingeniørforening and Norsk Elektroteknisk Forening.

Membership

Recommended for Transfer

The board of examiners, at its meeting on September 12, 1940, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Anderson, A. E., application engineering section, General Electric Company, Philadelphia, Pa.
Bonnett, L. B., engineer of design and planning, Consolidated Edison Company of New York, Inc., New York, N. Y.
Kurtz, W. O., vice-president, Illinois Bell Telephone Company, Chicago, Ill.
Landis, G. G., chief engineer, Lincoln Electric Company, Cleveland, Ohio.
Perkins, C. A., professor of electrical engineering, University of Tennessee, Knoxville, Tenn.
Reiber, A. H., engineer of development and research, Teletype Corporation, Chicago, Ill.
Richmond, H. B., treasurer, General Radio Company, Cambridge, Mass.
Schregardus, Dirk, transmission engineer, The Ohio Bell Telephone Company, Cleveland, Ohio.

8 to Grade of Fellow

To Grade of Member

Conrad, A. G., associate professor of electrical engineering, Yale University, New Haven, Conn.
Garrett, A. M., staff engineer, Commonwealth Edison Company, Chicago, Ill.
Hammond, W. W., electrical engineer, Copper Wire Engineering Association, Washington, D. C.
Hickey, M. G., transformer designing engineer, The Hackbridge Electric Construction Company, Walton-on-Thames, Surrey, England.
Hope, H. L., superintendent of equipment engineering, Western Electric Company Inc., Chicago, Ill.
Johnson, E. E., in charge of aeronautics, General Electric Company, Schenectady, N. Y.
Norris, C. B., assistant professor of electrical engineering, Tulane University, New Orleans, La.
Stringham, L. K., development engineer, Lincoln Electric Company, Cleveland, Ohio.
Taylor, C. W., electrical engineer, Sargent and Lundy, Inc., Chicago, Ill.
Thomason, J. L., engineer, General Electric Company, Pittsfield, Mass.
Ward, T. V., deputy chief electrical inspector, District of Columbia Government, Washington, D. C.

11 to Grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical Districts. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before October 31, 1940, or December 31, 1940, if the applicant resides outside of the United States or Canada.

United States

1. North Eastern

Hutchinson, C. L. (Member), E. I. du Pont de Nemours and Company, Buffalo, N. Y.
Truesdell, F. W., General Electric Company, Lynn, Mass.
Webb, D. R., General Electric Company, Schenectady, N. Y.

2. Middle Eastern

Dugan, M. J. A., Philadelphia Electric Company, Philadelphia, Pa.
Eaches, A. R., Philadelphia Electric Company, Philadelphia, Pa.
Greene, D. L., The Utility Management Corporation, Reading, Pa.
Kassimir, W. J., Atlantic Refining Company, Philadelphia, Pa.
Maeda, Y., Mitsubishi Electric Company, care Foreign Engineering Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Ruggieri, M. L., Line Material Company of Pennsylvania, East Stroudsburg, Pa.
Schlegel, R. D. (Member), United States Engineers, Washington District, Gravelly Point, D. C.
Smith, C. E., New York Shipbuilding Corporation, Camden, N. J.
Wood, R. M. (Member), Rural Electrification Administration, Washington, D. C.

3. New York City

Bruun, S. W., Consolidated Edison Company of New York, Inc., New York, N. Y.
Dickerhoff, J. F., Long Island Lighting System, Mineola, N. Y.
Hausner, H. H. (Member), American Electro Metal Corporation, Yonkers, N. Y.
Haythorne, K., Acorn Insulated Wire Company, Brooklyn, N. Y.
Henschel, W., Westinghouse Electric and Manufacturing Company, New York, N. Y.
Hughes, D. A., Public Service Electric and Gas Company, Irvington, N. J.
Keyser, J. A., Public Service Electric and Gas Company, Paterson, N. J.
Works, C. N., Phelps Dodge Copper Products Corporation, Yonkers, N. Y.

4. Southern

Bishop, E. L., Knoxville Electric Power and Water Board, Knoxville, Tenn.
Talmage, T. D. (Member), Tennessee Valley Authority, Chattanooga, Tenn.

5. Great Lakes

Abbott, W. R., Iowa State College, Ames.
Duernberger, A. F., Wagner Electric Corporation, Detroit, Mich.
Kelb, A. J., Michigan Bell Telephone Company, Saginaw.
Johnston, T. F., Iowa State College, Ames.
Solomon, D. L., Estate of H. M. Friendly, Trust, Chicago, Ill.

6. North Central

Oestreich, H. J. (Member), General Public Utilities, Inc., Deadwood, S. Dak.

7. South West

Grazier, J. C., Electro Geophysical Exploration Company, Houston, Tex.

8. Pacific

Howard, J. H., Southern California Edison Company, Ltd., Los Angeles, Calif.
Neuman, M. K., City of Los Angeles Department of Water and Power, Los Angeles, Calif.
West, H. L., Bureau of Power and Light, Los Angeles, Calif.

9. North West

Buergey, I. J., Anaconda Copper Mining Company, Great Falls, Mont.
Driver, P. C., Washington Water Power Company, Spokane.
Kanzler, W. H., Bonneville Power Administration, Portland, Ore.

Total, United States, 35

Elsewhere

Boul, J. E., English Electric Company, Ltd., Stafford, England.
Radin, E. L., Lago Oil and Transport Company, Ltd., Aruba, N. W. I.
Rissik, H. (Member), International Standard Electric Corporation, London, S.W.6, England.

Total, elsewhere, 3

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the addresses as they now appear on the Institute record. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Barnes, Frank P., Y. M. C. A., Schenectady, N. Y.
Buehler, Everett F., 17 1/2 E. Side Square, Macomb, Ill.
Armand F. Du Fresne, General Petroleum Co., Los Angeles, Calif.
Edie, Leslie C., 309-A W. 35th St., Austin, Texas.
Johnson, James Steven, 59 W. Bridge St., Oswego, N. Y.
Johnson, Louis, Jr., 1801 G St., N.W., Washington, D. C.
Johnson, W. B., 133 Helen Ave., Mansfield, Ohio.
Lindahl, Melvin A., 41 Wendell Ave., Pittsfield, Mass.
Lundberg, Fred C., 2728 S. 11th East, Salt Lake City, Utah.
McKee, Herbert W., 1313 N. State, Chicago, Ill.
O'Connell, Allen W., 453 E. Main St., Murfreesboro, Tenn.
Ponti, Prof. G. G., Corso re Umberto 77, Turin, Italy.
Rohwer, Orville J., 732 Bittersweet Place, Chicago, Ill.
Ward, Lewie M., Garden City, Kans.

14 Addresses Wanted

Of Current Interest

From A E C • •

ITEMS appearing under this heading are from the news service of American Engineering Council.

Defense Program Advances

With leases negotiated for the establishment by the United States of a string of air and naval bases in British territories from Newfoundland to Guiana, a joint commission actively planning the co-ordination of United States-Canada defense plans, the appropriation by Congress of an additional $5,000,000,000 defense appropriation, the calling out by the President of the first National Guard units for intensive training, and passage by Congress of a bill for general conscription, the past month in Washington has witnessed notable advances in the program to tighten up national defense.

How much construction work will be necessary to prepare the new Atlantic bases for actual use has not yet been determined, but there is little doubt that the volume will be considerable and the urge for speed in development intense. Within a few hours of the consummation of the agreement by which they were made available to this country in exchange for 50 over-age destroyers, American officers were en route to inspect them and recommend a program of improvement.

The latest appropriation bill provides funds for the immediate ordering of 19,000 airplanes, equipment for an army of 2,000,000 men, and 200 warships, all previously authorized in earlier legislation. Its passage followed shortly after a report by the National Advisory Defense Commission that in its first three months contracts had been placed totaling $1,470,000,000 of the $1,800,000,000 previously voted for the Navy and $605,000,000 of the $2,300,000,000 earlier provided for the Army. This does not measure the full extent of defense orders placed, for the Commission does not pass on contracts involving less than $500,000, of which many have been awarded.

NEW PLANT CONSTRUCTION

These figures are expected to jump sharply as soon as Congress completes action on the pending tax bill, as the uncertainty of business in regard to profit limitations and its ability promptly to amortize expenditures for the expansion of plant facilities is retarding the award of contracts the fulfillment of which will require such expansion by private industry. This factor has not, however, affected the award of several large contracts for special plants to be owned by the Federal Government but built and operated by private industry under management contracts, including a $25,000,000 smokeless powder plant to be located at Radford, Va., and operated by the Hercules Powder Company; a second of the same size to be built for operation by du Pont at Charlestown, Ind., and a $20,000,000 factory to build Army tanks in the Detroit area, to be operated by the Chrysler Corporation.

Total expenditures for plant expansion and new equipment resulting from the defense program are estimated to total from $2,500,000,000 to $3,000,000,000 during 1941, according to the Department of Commerce. Normal peace-time expenditures in these categories have been not less than $2,000,000,000 during 8 years in the last 20, according to preliminary estimates from the same source, but dropped to one-third of this amount in 1932 and 1933.

The Defense Commission has worked out a form of contract that will enable businessmen receiving defense contracts involving new plant construction to use them as a basis for financing such facilities, but before this can be put into effect Congress must amend present laws prohibiting a Federal contractor to assign his rights to another. The Commission points out that new plant construction can be grouped roughly into three categories:

1. Those of which the output would be useless in normal times, such as gunpowder plants; these will be built and owned by the Federal Government, but operated by private industry under management contracts.

2. Factories making products for which there would be an uncertain demand in peace times; these would be financed under the new form of contract under which the Government would contract to pay, in five annual installments, for the cost of facilities, with provision for the determination by arbitration, at the end of the five-year period, of the equity in the plant to be held by the Government. With this determined the manufacturer could either purchase this equity at the determined value, or alternatively leave title with the Government, which would maintain its share in the property as stand-by equipment, or sell it elsewhere.

3. Factory expansions needed to make extraordinary quantities of normal goods. Capital so invested would be protected by permitting the cost of new facilities to be amortized in five years from profits.

AIRCRAFT PRODUCTION RISES

Although these same uncertainties affect the production of airplanes, and this industry is in addition subject to profit limitations on government contracts, pressure for production from at home and abroad is so intense that a number of manufacturers have embarked upon major plant expansion programs in the expectation that Congress will make equitable adjustment of present laws.

The Reconstruction Finance Corporation has granted loans covering new and expanded plants and equipment for airplane and engine construction to the following: Curtiss-Wright Company, $51,000,000; Bendix Aviation Corporation, $18,587,855; Boeing Aircraft Company, $10,500,000. Curtiss-Wright will build a new airplane-engine plant to employ 12,000 workers at Lockland, Cincinnati, Ohio, and another new plant at St. Louis, Mo., and will expand its existing Buffalo, N. Y., plant. The Bendix loan will be used to expand several of its present factories. Boeing intends both to expand its Seattle, Wash., plant and to construct a new unit at Wichita, Kans.

An order for 17,000 airplane engines to cost about $180,000,000, to be delivered to both the Army and the Navy during the fiscal years 1941 and 1942, has been awarded to the Pratt and Whitney division of United Aircraft Corporation. Its fulfillment will require the immediate expansion of the company's plant at Hartford, Conn., to the extent of some $2,500,000 for buildings, which will be supplied by the company, and $7,000,000 for equipment, to be bought and owned by the Government.

As of August 29, contracts had been signed covering the construction of 7,321 military planes, with 3,654 more being built under "letters of intention" pending the completion of formal contracts. For the first six months of 1940, the Department of Commerce reported that exports of airplanes, engines, and accessories had nearly tripled as compared with the first half of 1939, climbing to a total value of $138,388,046. President Roosevelt predicted that by January production of planes would be at the rate of from 13,000 to 14,000 per year. Subsequently to the compilation of the figures given above, orders were given to Boeing for 277 four-engine long-range bombers to cost $70,449,955, and to Lockheed for 410 interceptor-pursuit planes for $30,278,787.

LABOR

Vocational training to meet the demand for skilled labor is "one of the swiftest-moving phases of the defense program", according to Paul V. McNutt, Federal Security Administrator, who reported that 20,000 workers had been graduated from training courses by the end of August. The program was started in July and during its first month enrolled 80,614 persons in 283 cities in courses in such subjects as blueprint-reading, lathe work, milling, welding, pattern-making, sheet-metal work, foundry and machine-shop practice. A plan for the use of the Civilian Conservation Corps as a means of training young mechanics and artisans for defense industries is in preparation.

HOUSING

Shelter for the thousands of new workers to be engaged in defense industries is providing a troublesome problem. The Defense Commission has estimated an immediate need for 110,000 dwellings, with an additional 50,000 necessary when new plants now under construction go into operation. The Navy has been allotted $10,000,000 by President Roosevelt, which will be added to $40,000,000 loaned by the Reconstruction Finance Corporation for construction of housing facilities in areas where the need is acute. Meanwhile several bills appropriating large sums for this specific purpose are awaiting consideration by Congress.

MILITARY PERSONNEL

Approved by both houses of Congress, the first peace-time conscription bill in the history of the United States calls for registration of men between 21 and 36 years of age for selective military service. The bill, which becomes effective, immediately includes provision for the drafting of property as well as men by giving the Government authority to take over on a leasing basis factories of suppliers, if satisfactory contracts cannot be arranged.

Testimony presented by high Army officials during consideration of the bill revealed that the Army now has on hand equipment sufficient to train 3,000,000 men, although it is deficient in the newer types of material used by the mechanized arms; that a shortage of officers limits the effective number of new conscripts to 400,000 immediately and 1,200,000 by the end of a year; that an Army of "three or four million men" would be necessary "to prevent hostile infiltration in this hemisphere".

Passage of a bill giving the President authority to call to active duty members of the National Guard was followed immediately by the ordering of 60,000 men in that organization into active service from 26 states. They will be given a full year of training, beginning September 26. The War Department also revealed its intention to call to active service 51,000 reserve officers now on the inactive list. Consideration is being given to the exemption from both calls of men actively engaged in defense industry whose services would be of greater value to the nation in their present jobs.

Program Suggested to Help Pan-American Relations

Following up a conference with State Department officials, AEC's committee on inter-American engineering relations, of which C. O. Bickelhaupt (M'22, F'28) is chairman, has recommended the adoption by Council of the following program to aid in the development of cultural and other relations between engineers in the United States and other countries in the Western Hemisphere:

1. Foster additional scholarships in engineering schools of the United States for students from Pan-American countries, and the exchange of scholarships with such countries.

2. Establish in New York a headquarters for visiting engineers to help them in planning inspection trips to engineering projects and manufacturing plants, and in making travel arrangements.

3. Arrange for the exchange of engineering publications, information, and similar material.

The committee has further recommended that the executive secretary be authorized to work with the committee in carrying out these recommendations.

Development of Industry in West Urged

Establishment of essential war industries in the Pacific Coast area to provide a better balance to national defense is urged in a report recently submitted to the National Defense Advisory Commission by the Department of the Interior. Low-cost hydroelectric power from Federal projects, in addition to mineral and other resources, make possible the setting up in this area of facilities that would eliminate the present necessity of shipping raw and processed materials thousands of miles to supply the needs of the Far West, as well as Hawaii and the Philippine Islands, it is argued. Specifically mentioned as possible of immediate development are the following defense products: aluminum, magnesium, and alloy steels for aircraft engines, ordnance, and ship-building; brass for shell casings and fuses; synthetic nitrogen for explosives; plastics for airplane parts.

Power from the Grand Coulee development on the Columbia River, to be completed in 1941, will be combined with that from the Bonneville project, now in operation, for marketing throughout the Pacific Northwest, according to a decision by the Department of the Interior. The two plants will be linked together by transmission lines that will also distribute the power widely throughout the region. Contracts have already been executed for the use of large blocks of this low-cost power with the Aluminum Company of America and the Sierra Iron Company.

Industry • • • •

Power Companies Order New Generators

Orders for four turbine generators with capacities ranging from 50,000 to 60,000 kw have been placed recently by eastern and southern utility companies. Georgia Power Company has ordered from General Electric Company a 60,000-kw condensing turbine generator with surface air cooler, to be installed in Plant Atkinson, Atlanta, Ga., doubling the capacity of the station. The generator is rated 66,667 kva, 13,800 volts, and 1,800 rpm.

Consolidated Gas, Electric Light and Power Company of Baltimore has ordered a 52,000-kw turbine generator from General Electric, a duplicate of another now being built for the company. The two will be 3,600-rpm tandem-compound double-flow units with steam conditions of 850 pounds pressure and temperature of 900 degrees Fahrenheit. Generators will be hydrogen cooled.

A 50,000-kw turbine generator, also a duplicate of a unit now being installed, has been ordered from General Electric by the Potomac Electric Power Company for its Buzzard Point station at Washington, D. C. Both are 1,800-rpm single-casing single-flow turbines, with steam conditions of 650 pounds pressure and temperature of 900 degrees Fahrenheit.

The Consolidated Edison Company of New York, Inc., has ordered from the Westinghouse Electric and Manufacturing Company a 50,000-kw hydrogen-cooled superposed turbine generator, to be installed in the Sherman Creek station, New York, N. Y. The 3,600-rpm turbine is designed for steam conditions of 1,500 pounds pressure and temperature of 950 degrees Fahrenheit, representing the highest steam pressure on the company's system.

TVA Orders Steam and Hydro Equipment

Expansion of power facilities of the Tennessee Valley Authority in connection with the national defense program has already resulted in several large orders for equipment, manufacturers report. Speed is being urged in the production of all the equipment.

For the new steam power plant to be built at Watts Bar, Tenn., two 60,000-kw 1,800-rpm air-cooled turbine generators have been ordered from General Electric Company. Steam will be supplied to each of the turbines at a pressure of 850 pounds per square inch and a temperature of 900 degrees Fahrenheit. The new plant, TVA's first steam plant, is expected to go into operation early in 1942.

General Electric has received orders also for three waterwheel generators for the powerhouse of the Cherokee Dam project, near Jefferson City, Tenn. Each of the air-cooled units is rated 33,333 kva, 13,800 volts, and 94.7 rpm.

Contracts for one hydraulic turbine for the Pickwick Landing Dam project and two hydraulic turbines and two generators for the Wilson Dam project have been given to Allis-Chalmers Manufacturing Company. The Pickwick Landing hydraulic turbine is rated 48,000 horsepower at 81.8 rpm with a 43-foot head; those for the Wilson Dam each are rated 35,000 horsepower at 100 rpm with 92-foot head. The generators, of the "umbrella" type, are rated 28,000 kva, 13,800 volts, and 100 rpm.

Television Pioneer Dies. Doctor Paul Nipkow, inventor of the "Nipkow disk" which played an important part in the development of television, died in Berlin, Germany, August 24, 1940, at the age of 80. In 1884 he patented an invention known as the "electrical telescope", but the patent lapsed because he was unable to meet the cost of extending it. The device he invented has been superseded, but the principle of scanning which he developed is still indispensable to television. In 1934 Doctor Nipkow was elected honorary president of the newly founded German Television Society.

Other Societies •

NRC Insulation Conference to Meet in Washington

The conference on electrical insulation of the National Research Council, division of engineering and industrial research, will hold a three-day meeting in Washington, D. C., beginning October 31, 1940. The meeting will be held at the headquarters of the National Research Council in the building of the National Academy of Sciences. It is the 13th annual session of the conference.

As in other years, there will be reports on current investigations covering different aspects of dielectric problems which should prove interesting and stimulating to workers in this field. Any one interested and not on

Future Meetings of Other Societies

American Institute of Mining and Metallurgical Engineers. Joint meeting, AIME Coal Division, ASME Fuels Division, November 7–9, 1940, Birmingham, Ala.

American Institute of Physics. Conference on applied nuclear physics, with Massachusetts Institute of Technology, October 28–November 2, 1940, Cambridge, Mass.

American Physical Society. 237th meeting, November 22–23, 1940, Chicago, Ill.

238th meeting, December 1940, Pasadena, Calif.

239th meeting (annual meeting), December 26–28, 1940, Philadelphia, Pa.

American Society of Civil Engineers. Fall meeting, October 16–18, 1940, Cincinnati, Ohio.

Annual meeting, January 15–18, 1941, New York, N. Y.

American Society of Heating and Ventilating Engineers. Fall meeting, October 14–15, 1940, Houston, Tex.

Annual meeting, 4th week in January, 1941, Kansas City, Mo.

American Society of Mechanical Engineers. Annual meeting, December 2–3, 1940, New York, N. Y.

American Welding Society. Annual meeting, October 20–25, 1940, Cleveland, Ohio.

Conference on Electrical Insulation (National Research Council). October 31–November 2, 1940, Washington, D. C.

Engineers' Council for Professional Development. Annual meeting, October 24, 1940, Pittsburgh, Pa.

National Electrical Contractors Association. Fall meeting, October 21–23, 1940, Jacksonville, Fla.

National Electrical Manufacturers Association. Annual meeting, October 27–November 1, 1940, New York, N. Y.

American Society for Metals. National Metal Congress. October 20–25, 1940, Cleveland, Ohio.

Society of Automotive Engineers. National aircraft production meeting, October 31–November 2, 1940, Los Angeles, Calif.

the mailing list of the conference may obtain a program for the meeting by writing the secretary of the conference, Thorstein Larsen, Consolidated Edison Company, 55 Johnson Street, Brooklyn, N. Y.

CHEMISTRY REPORT

The committee on chemistry of the conference on electrical insulation recently issued its annual report on "Contributions of the Chemist to Insulation Research July 1938 to June 1939". The mimeographed report summarizes developments in various fields and includes a bibliography of 419 items. Copies may be obtained on request to F. L. Miller, chairman, committee on chemistry, Esso Laboratories Research Division, Elizabeth, N. J.

Education • • •

Armour and Lewis Institutes Merged as Illinois Institute of Technology

Consolidation of Armour Institute of Technology and Lewis Institute into Illinois Institute of Technology was completed July 24, 1940, when the boards of trustees of the merging institutions met as a joint board to confirm the consolidation and elect officers. Henry T. Heald, president of Armour since 1938, was elected president of the new institution. James D. Cunningham, chairman of the board of Armour Institute, was elected chairman of the new board, and Alex D. Bailey, chairman of the board of Lewis Institute, was elected vice-chairman. Plans for the merger were first announced in October 1939 (*EE, Dec. '39, p. 528*).

Upper-class engineering courses are to be given at the Armour campus; liberal arts courses at the Lewis campus. The division of engineering is to be known as the Armour College of Engineering of Illinois Institute of Technology; the division of arts and sciences as Lewis Institute of Arts and Sciences of Illinois Institute of Technology. During the academic year 1940–41 efforts will be made to co-ordinate courses and eliminate duplication. Full-time instructors of both divisions are expected to number about 200, and the combined day and evening enrollment will be about 7,000 students.

President Heald, whose connection with Armour began as assistant professor of civil engineering in 1927, was born in 1904 and received the degree of bachelor of science in civil engineering from the State College of Washington in 1923 and that of master of science from the University of Illinois in 1925. He was employed as an engineer by the United States Bureau of Reclamation, the Illinois Central Railroad, and the Chicago Board of Local Improvements, before beginning his career at Armour. He became associate professor and assistant dean in 1931, dean of freshmen 1933, professor and dean of the college in 1934, and president in 1938.

Letters to the Editor • • •

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

In Memoriam: Percy H. Knight

To the Editor:

There passed away on May 3, 1940, at Costa Mesa near Newport, Calif., an engineer who was known and loved by a host of our membership, although on account of his infirmities and his desire to remain as inconspicuous as possible he never could induce himself to take any part in our Institute activities. I refer to Percy H. Knight, formerly a prominent electrical engineer of the Westinghouse Electric and Manufacturing Company who had been a helpless and brave sufferer from the effects of his terrible experience at the beginning of the century with the then highest transmission voltage of 33,000 volts.

While he nearly lost his life, and suffered in silence all these years, he never would permit anyone to render to him the honor he deserved as being one of our heroes, and he was more entitled to the medals and rewards than most of those to whom such honors have been awarded.

Nobody knows how many engineers and others who lost their hands and were completely discouraged were braced up and fitted to go on with life by his counsel and the use of his inventions, which he gave freely to all who needed without recompense.

The United States Government consulted Percy during the war and availed themselves of his counsel and his appliances to rehabilitate the wounded soldiers.

All of these people and more will be saddened by his passing and will be sorry they cannot at least put a wreath on his grave in California. As to myself, who was his chum at college and possibly his closest friend till the last, I feel that his record should be available to the Institute and I am appending a brief synopsis of his engineering career.

(*Editor's note:* Percy H. Knight was an Associate of the Institute 1902–12.)

Percy H. Knight was born in Chautauqua County, N. Y., graduated at Cornell University in 1892 as an electrical and mechanical engineer, and was at once engaged by the Westinghouse Electric and Manufacturing Company as an erecting engineer. As such he was sent out to superintend erection of many important electrical power plants and other installations during the pioneer days of the street railway and of the introduction of alternating current. His work was originally in the big Eastern cities, but near the close of the century his activities took him to the high-voltage transmission systems of the West, where he represented the Westinghouse company as one of their most competent and most valuable superintending engineers. After some of his experiences on the systems in the vicinity of Salt Lake City and Denver he was put in charge of all of the engineering work in the San Francisco district.

Up to this time, the alternating current in the United States had been introduced at Niagara Falls and highest transmission voltage was about 22,000 volts. The Niagara Falls Power Company had solved their problem of utilizing the head of water above the Falls by sinking the wheel pit to the level of the tail race and utilizing a tall shaft from the bottom of the wheel pit, where the huge turbines were located to drive the Westinghouse a-c dynamos which were located in the power plant at the top of the tall shaft. On account of the weight of this long shaft, there were internationally known engineering firms and intensive investigations involved in designing the water wheel and bearing design, which attracted the interest of the whole engineering profession. The solution was finally reached by the utilization of the famous step bearings which have been in successful operation ever since.

Just after this plant was proved to be a success, the Snoqualmie Falls Power Com-

pany resolved to tackle a smaller problem of the same nature, to supply power to the City of Seattle and that district. They finally decided, instead of using a long shaft, to dig out a large chamber in the rock under the river bed with a tall penstock upward to the surface above, with the dynamos and water wheels at the bottom in the rock chamber. The power was generated at low voltage and the conductors carried up the penstock and to banks of step-up transformers on the river bank. The switchgear and all control were located at the generating plant. The Westinghouse Electric and Manufacturing Company was awarded the contract for this work and I had charge of the design and building of this control equipment. We put carbon-break circuit breakers in the low-voltage circuits and the feeder lines to the transformers were provided with exceedingly reliable carbon break automatic circuit breakers. We were not responsible for the high-voltage equipment or control. The company decided to step up the low voltage to 33,000 volts for transmission to Seattle, and tie the whole high-voltage system solidly together, relying on the insulation and the low-voltage carbon-break circuit breakers to control the power supply.

Having no experience with operation of such high-voltage equipment, the chief engineer of Snoqualmie Power Company appealed to the Westinghouse company for the loan of a superintendent and Percy Knight was sent out. His duties involved breaking in and training an operating force. Among these was a young college man with a wife and children, who was chief lineman.

One day in the Seattle substation this man was up in a high concrete gallery where the high lines connected to the lightning arresters, tightening some bolts, and Percy heard him scream. Realizing something dangerous was happening, and fearing to send inexperienced men up, he went up there himself. Carefully getting on a dry plank he grabbed the man's clothes and pulled him off the ironwork where he lay. But the man was so burned he died next day. But Percy in straightening up got too near a roof strut and 33,000 volts hit him in the neck and the flash burned him to his right foot, a big burned stripe. He was thrown, and grabbed the iron gallery rail, to save himself from being dashed to the floor below. But it developed that the high line had a leak through the roof bushings, and the whole of the iron work was alive with a charge of 33,000 volts, which had already injured the lineman, and nobody knew it. So Percy got it through this iron rail. But before the current reached this rail, it had to pass through several feet of brick wall into which the rail was anchored. This furnished a high-resistance path through the wall. Percy had the misfortune to fall with a heel on the ground wire from the lightning arresters, and thus being under a severe shock, he was unable to let go the rail, and was being electrocuted slowly. In the meanwhile one of his men had presence of mind to get to the top of the substation and throw a wire over the high-voltage lines. This made a short circuit and my low-voltage breakers at the power plant automatically opened and shut down all the power.

When they took Percy down, his heel came off with his shoe; his Achilles tendon was burned off; he had a big burned strip from his neck to the heel; and he had a hole in the leg below the knee in the flesh and bone big enough to hold a door knob. This was too weak to support an artificial foot.

At the Seattle hospital they finally had to amputate the hands, bit by bit, till they were taken off halfway to the elbows. At that, the Westinghouse company telegraphed Percy that he should have a good position with that company, irrespective of his injuries, as long as he desired to work.

While he was swathed with bandages, it is understood that a doctor came in from attending a smallpox patient and Percy contracted the disease and had to suffer this also. The nurses at the hospital were greatly attracted to our Percy, and on account of his cheerfulness and grit, they delighted in sitting around his bed in groups to cheer him up. One nurse, named Marion Mowat, an only daughter of a wealthy lumberman, had determined to give herself a useful occupation. Meeting him in the hall in a wheeled chair one day, she was attracted to him and afterward made his acquaintance, and finally engaged herself to marry him.

After investigation of all the artificial hands and contrivances for cripples, Percy discarded them all and finally designed a pair of arm sockets, with straps, and sets of appliances, and some steel hooks, all with shanks and quick-fastening devices, so that he could dress completely, shave, brush his teeth, handle the telephone, write with pencil and pen, and eat with special table ware. He then tried these out to rehabilitate some unfortunates in Seattle who have loved him ever since. No one knows how many he helped.

Afterward he came to Pittsburgh and although on crutches, on account of his bad foot, he took a position as chairman of the defective accounts committee, a very important occupation, which he held as long as he worked.

One week-end, the engineering offices were moved, and the company had men giving the place a scrub-down after the move. Percy went up to see that his belongings were properly moved and in shape for work. His crutch slipped on the soapy floor and he broke his bad leg near the hip. That put him in bed for weeks and shortened his leg. His mother, who had been with him constantly, told me that was the first time he had apparently lost his nerve. After the leg healed the doctors fixed him up with a special shoe and a steel brace, and for years afterward he was able to walk with a limp. Later he lost this leg.

The next important event was his meeting the nurse by appointment in Boston where they were married. They wrote me of it, and when the boys found it out they appointed Charles F. Scott and myself a committee to procure a wedding remembrance and show their admiration. By the marriage, Percy had a girl Ruth, and three fine boys.

After about 41 years of service the Westinghouse company retired Percy on account of age. About two years afterward he was completely paralyzed and was an invalid till his death May 3, 1940, at Costa Mesa, Calif.

BERTRAND P. ROWE (A'03,F'13)

(Electrical engineer, 361 West California Avenue, Glendale, Calif.)

Books Received

"Flash! Seeing the Unseen by Ultrahigh-Speed Photography." A collection of photographs taken at extremely short exposures, with suitable introductory and descriptive material, is reproduced in this book by Harold E. Edgerton (M'32) and James R. Killian, Jr. The method of taking these photographs consists of using an extremely intense light flash of extremely short duration (less than $^{1}/_{50,000}$ second) produced by a special type of gaseous-conduction lamp with associated circuit. The book illustrates admirably the effectiveness of this method of studying high-speed motion of all types. It comprises 203 pages and measures $8^{1}/_{2}$ by $11^{1}/_{4}$ inches; published by Hale, Cushman and Flint, Inc., Boston, Mass., $3.00 per copy.

"Lessons in Arc Welding." A series of 51 lessons which form the basis of instruction at the Lincoln Arc Welding School has been published by the Lincoln Electric Company, Cleveland, Ohio. The manual, which contains 144 pages and is illustrated, is intended to present fundamentals of welding, knowledge of which will enable the operator to use the welding process. Price per copy, 50 cents in the United States; 75 cents elsewhere.

The following new books are among those recently received at the engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ROYAL TECHNICAL COLLEGE JOURNAL, Glasgow, Scotland, volume 4, part 4, January 1940, pages 607–796. Robert Anderson and Sons, Ltd., Glasgow, C1. Illustrated, 10 by 7 inches, paper, 10s.6d. Record of some of the research carried out in the college by the staff and senior students. The topics of the 15 papers include investigations in physical chemistry, metallurgy, mechanics, aerodynamics, electrical measurements, mining, etc. List of other publications by members of the college.

FUNDAMENTALS OF ELECTRICITY AND ELECTROMAGNETISM. By V. A. Suydam. D. Van Nostrand Company, New York, 1940. 690 pages, illustrated, 9 by $5^{1}/_{2}$ inches, cloth, $4.75. Fundamental laws, theories, and principles presented in such a way as to provide a foundation both for the physicist and for the electric-power and communication engineer. The field from electrostatics to thermionic electron tubes is covered with as full mathematical development as is consistent with the student's previous instruction. Problems and literature references.

INDUSTRIAL DESIGN. By H. Van Doren. McGraw-Hill Book Company, New York, 1940. 388 pages, illustrated, $9^{1}/_{2}$ by 6 inches, cloth, $4.50. A practical textbook on industrial design, expected to be useful to the engineer, commercial artist, and businessman as well. Contains an elementary treatise on designing in three dimensions, discussion of technique, information on materials and processes, problems, and case histories of the development of three actual products.

INDUSTRIAL ELECTROCHEMISTRY. (Chemical Engineering Series.) By C. L. Mantell. Second edition. McGraw-Hill Book Company, New York, 1940. 656 pages, illustrated, $9^{1}/_{2}$ by 6 inches, cloth, $5.50. Covers the theoretical and technical sides of electrochemistry, the aqueous and fused electrolyte industries, electrothermics, the electrochemistry of gases, and such engineering aspects as power generation and the materials used in the construction of electrochemical equipment. New material has been added in this edition and some rearrangement of topics made.

PRINCIPLES AND PRACTICE OF ELECTRICAL ENGINEERING. By A. Gray, revised by G. A. Wallace. Fifth edition. McGraw-Hill Book Company, New York, 1940. 586 pages, illustrated, 9 by 6 inches, cloth, $4.00. Revision of a standard textbook covering a considerable range of electrical theory and machinery, including control and applications, with a minimum of mathematical derivation.